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POLLEN ANALYTICAL INVESTIGATIONS IN THE NORTHERN NETHERLANDS
WITH SPECIAL REFERENCE TO ARCHAEOLOGY

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CONTENTS

I. INTRODUCTION

For many years already there has been a close co-operation between archaeology and palynology. This co-operation is particularly concerned with the investigation of archaeological objects—sometimes even complete settlements—which were discovered in the peat. With the help of archaeologically well datable finds it was possible to obtain a dating of some parts of the pollen diagram and of stratigraphical phenomena as the recurrence surfaces in the Swedish raised bogs. Next, objects which were archaeologically not datable, viz. trackways and peat burials, could be dated more or less accurately by means of pollen analysis. In the last few years, moreover, attention has been paid to the pollen analytical investigation of samples from burial monuments. It was Waterbolk who worked out this method, and who attained important results.

In this investigation much stress is laid on the correlation between archaeological and scientific phenomena. In this connection it was in the first place of much importance to have the disposal of a detailed diagram from a large raised bog whose pollen content cannot have been influenced to a great extent by local conditions. From this diagram reflecting the vegetation development in a given region alterations of the vegetation effected by climatic changes or human inter-

ference can be read. Moreover, by means of such a diagram other pollen analytical data from that given region—which have often been influenced by local conditions—can be compared better with those from other regions.

In order to be able to compare accurately the results of the palynological investigation of burial monuments with the results of the peat investigations, it was necessary to know what part of the diagram corresponds with the Neolithic, Bronze Age and Iron Age respectively. The pollen analytical investigation of some Dutch finds from raised bogs and that of other—already published—finds from north-west Germany and Denmark could procure the data for an archaeological dating of the pollen diagram.

The study of the raised bog from south-east Drente led naturally

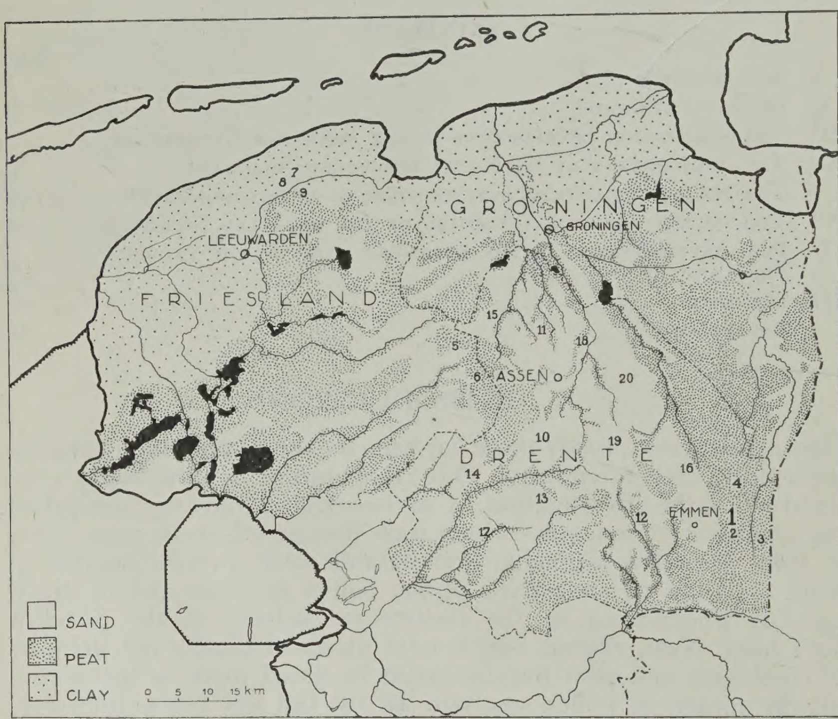

Fig. 1. Map of the northern Netherlands showing the localities referred to in this paper.

1, Raised bog near Emmererfscheidenveen. 2, Bronze dagger near Bargeroosterveld. 3, Roman coins near Bargercompascuum. 4, Bronze find of Roswinkel. 5, Late-glacial deposits near Haule. 6, Raised bog near Fochteloo. 7, Peat covered by marine clay near Lichtaard. 8, Peat covered by marine clay near Jislum. 9, Peat covered by marine clay near Klaarkamp. 10, Barrow cemetery near Hijken. 11, "Noordse Veld" near Zeijen. 12, Anglo-Saxon cemetery near Zweeloo. 13, Barrow cemetery near Wijster. 14, *Hunebeds* and tumuli in the vicinity of Diever. 15, *Hunebed* near Steenbergen. 16, *Hunebed* near Exloo. 17, Tumulus near Ruinen. 18, Tumulus near Oudemolen. 19, Tumulus near Schoonloo. 20, Tumuli near Eext.

to an examination of the pollen analytical position of the so-called *Grenzhorizont*. During the last few years opinion has greatly differed on the dating of the *Grenzhorizont* which has often been used to date archaeological objects lying not far below or above this contact surface.

In connection with the view held by some authors that there would be a correlation between the height of the sea level and the peat formation, an investigation into the flooded peat layers from the coastal region of the northern Netherlands was desirable. On account of the fact that from the coastal region of the province of Groningen no suitable profiles could be obtained, this part of our study, however, remained very incomplete.

II. GENERAL METHODS

Sampling technique

a. Peat samples. As in most cases peat walls showing good sections were available, and in some others it was possible to dig a hole in which the stratigraphy could be noticed, the use of a peat borer could nearly always be avoided. In general a complete or partial profile was sampled in sample tins. These tins have a length of 30 cm, a breadth of 3 cm and a depth of 3.5 cm. Mostly it is rather easy to push them into the peat wall, and by sticking a spade or knife behind them the tins are recovered filled with peat. In this way a profile can be "tinned" without much difficulty in a short time. By pinching a strip of parchment paper between the tin and the lid the drying up is highly reduced, so that the contents will remain moist for a long time.

b. Sand samples. This method cannot be recommended for collecting sand samples. The layer which has to be investigated, *e.g.* the old surface level or a sod of a barrow, is mostly not thicker than one or a few cm. In the field such a humous layer can easily be recognized, and the profile section with the layer in question could be sampled in the way described above. As, however, in spite of precaution the sand in the tins dries up quickly, it becomes very difficult to recognize afterwards the humous layer in the tin. It is for that reason that always in the field only the layer in question was sampled, and that no complete or partial profile was collected. If the layer was thicker than 1 cm always the uppermost cm was sampled, so that corresponding layers could be compared. For a detailed description concerning the sampling of barrows etc. we may refer to Waterbolk (1954*b*, Chapter IV).

Preparation of samples

The samples for pollen analysis were prepared according to the method described by Faegri and Iversen (1950, pp. 62–3). This method is a modification of the acetolysis method introduced by Erdtman and Erdtman (1933), and which in course of time has been improved (*cf.* Erdtman, 1943). Staining was carried out by boiling in a water bath the residue to which a weak KOH solution and some drops of safranin were added. The quantity of safranin to be added depends on the nature of the sample. If after acetolysis there is much dye adsorbing material, *e.g.* charcoal or certain remains of plants, of course, more stain has to be supplied than in the case that practically only the pollen grains are stained. An overstaining can be improved by washing out with a weak alcoholic solution.

Although after acetolysis most pollen grains can be easily recognized without staining, a good staining is not superfluous as otherwise the risk to overlook the small, thin-walled pollen grains is not imaginary. Especially in preparations of sand samples in which the fragile pollen grains are often badly damaged a good staining proved to be very useful.

All sand samples were treated with HF as only decanting appeared to be insufficient.

PRESERVATION OF PREPARATIONS

The preservation of the counted slides is not well possible. In spite of sealing the cover-glass by a sealing wax air very often enters, especially if under the cover-glass some larger particles are present, which is nearly always so with preparations of sand samples. It is for that reason that not the counted slides but the unused part of the preparation liquid is preserved. Small glass tubes (contents about 0.5 cc) which can be closed by a rubber stopper are very suitable for this purpose. These tubes can be stored in perforated wooden blocks.

DIAGRAMS

a. Composition. The published diagrams are a combination of the composite and the dissolved type of diagram. The curves for *Ulmus*, *Tilia*, *Fraxinus*, *Fagus* and *Carpinus* whose pollen occurs in relatively low percentages in the peat deposits from the northern Netherlands are reproduced on an enlarged scale in an auxiliary diagram. Otherwise the often characteristic course of these curves would not show up. Concerning the herbaceous pollen the curves for *Gramineae*, *Cyperaceae* and *Ericaceae* are also reproduced in an auxiliary diagram, while the other herbaceous types and the spores are represented by means of partial diagrams, just as the pollen of *Hedera*, *Picea*, *Acer*, *Myrica*, [1] *Populus*, *Humulus* and sometimes of *Salix*.

The results of the analysis of the samples from barrows and other archaeological objects are reproduced in tables.

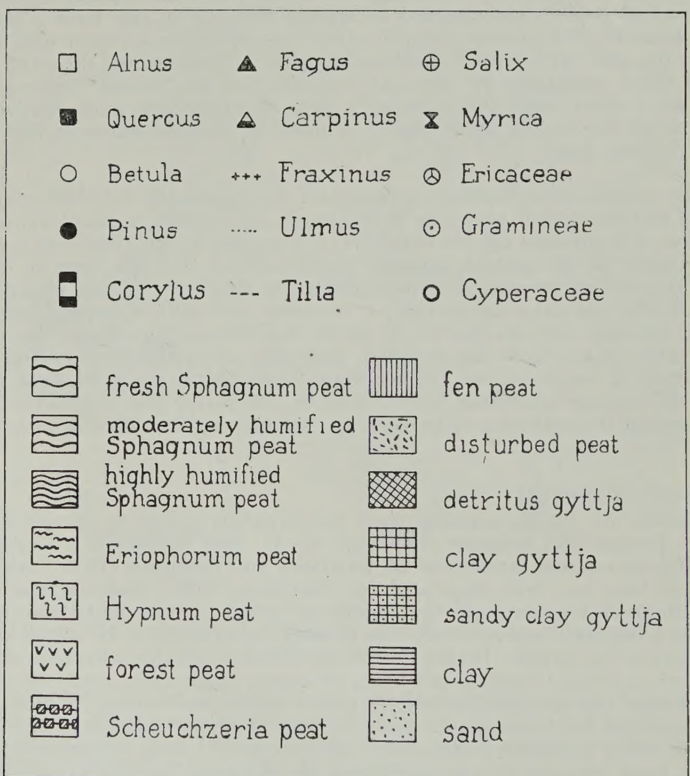

Fig. 2. Key to symbols for pollen diagrams.

[1] If *Myrica* was present in greater quantities a curve for this shrub is drawn in the auxiliary diagram with *Ericaceae*, *Cyperaceae* and *Gramineae*.

b. Quercetum mixtum. In contrast with a great number of published diagrams the pollen of *Quercus*, *Tilia*, *Ulmus* and *Fraxinus* are not combined here to the so-called *Quercetum mixtum.* Apart from phytosociological objections against this conception there are also pollen analytical objections. The *Quercetum mixtum* does not form a unit, because its constituents do not show the same behaviour. For instance *Ulmus* already reaches relatively high values in Boreal time when the values for *Tilia* and *Fraxinus* are still very low and *Quercus* also shows a relatively low value. In the first part of the Subatlantic time the *Tilia* percentages are insignificant and fall to zero after 400 A.D., whereas the other constituents still show rather high values. On that account the term *Quercetum mixtum* is avoided here, and the symbol of the *Quercetum mixtum* is used for *Quercus* alone.

c. Corylus in the tree pollen sum. Also in contrast with the usual method the pollen of *Corylus* is included in the tree pollen sum (ΣAP). Bertsch (1942, p. 38) did no longer exclude *Corylus* from the ΣAP, whilst later on Faegri and Iversen (1950, pp. 68 and 86–8) and Jonker (1952) put forward various arguments in favour of including *Corylus* in the ΣAP. For that reason these arguments will not be repeated here. Concerning the disadvantage that by including *Corylus* in the ΣAP these diagrams could not be compared with others, it may be remarked that in general the course of the curves does not show important changes by including *Corylus* in the tree pollen sum. The diagrams published in the present paper can be compared without difficulty with other diagrams whereby *Corylus* is not included in the ΣAP.

Tree pollen sum (ΣAP)

In a large number of samples about 1000 AP were counted. This large number of tree pollen was counted in order to obtain reliable curves for those types of pollen occurring in rather low percentages. This is true not only for the pollen of trees as *Ulmus*, *Tilia*, *Fraxinus* and others, but also for various herbs, *e.g. Rumex*, *Plantago*, *Artemisia* and *Chenopodiaceae.* When counting a rather small number of pollen grains the curves for the less abundant pollen types are too irregular. In spite of the high tree pollen sum, however, there always remains a chance of considerable deviations on account of the statistical error. For a discussion of the statistical error we may refer to Faegri and Iversen (1950, pp. 98–109).

If less than 1000 AP were counted in each sample this is mentioned in the diagram or in the text, as among others in the peat deposits from the northern part of the province of Friesland, which contain relatively few pollen grains.

Stratigraphy

Concerning the stratigraphy only the composition and the degree of humification of the concerning peat layers are given. A detailed investigation into seeds and remains of plants, which were not of much importance for the peat formation, was not carried out.

Although the measurements of the degree of humification according to Overbeck (Overbeck and Schneider, 1940; Overbeck, 1947) are much more exact than the so-called fist method, it was—especially on account of technical reasons—not yet possible to carry out these measurements. In most cases a good impression of the degree of humification can be obtained by dissolving a piece of peat in water.

III. THE VEGETATION DEVELOPMENT IN THE NORTHERN NETHERLANDS

As a basis for the palynological investigations discussed in the following chapters the preparation of a detailed diagram or series of diagrams was required which would give a reliable picture of the vegetation development in the northern Netherlands. Up to now a small number of diagrams from large raised bogs in the northern Netherlands has been published. These diagrams, however, are not

well suited for our purpose as the intervals between the analysed samples are too great, the number of pollen grains counted in each sample is too small, and practically no attention was paid to herbaceous pollen. WATERBOLK (1954*b*) published some detailed diagrams from small raised bogs in Drente which comprise only a part of the post-glacial vegetation development. Moreover, the pollen content of small bogs can have been greatly influenced by the local vegetation in the immediate vicinity of the bog, so that a close comparison with diagrams from large raised bogs is often difficult. Concerning the late-glacial period detailed diagrams are available by the investigations of VAN DER HAMMEN (1951). Because of the character of the vegetation local factors will not have been of much influence on the pollen rain in the small lakes in which *gyttja* was deposited.

Unfortunately no profile comprising the whole late- and post-glacial period could be found. Therefore the diagrams from three profiles were used. A *gyttja* profile not far from Haule (south-east Friesland) covers the late-glacial period—which only for the sake of completeness was investigated—and the beginning of the post-glacial period. The greater part of the post-glacial period is represented in a peat profile near Emmererfscheidenveen (south-east Drente), whilst the upper part of a diagram from the raised bog near Fochteloo (south-east Friesland) completes the last diagram. These three diagrams together give a practically complete picture of the late- and post-glacial vegetation development in the northern Netherlands.

Although, as far as possible, local influences were eliminated by collecting the samples from both post-glacial profiles at the centre of the bog, the concerning diagrams cannot simply be considered as standard diagrams of this region. Comparison with numerous other diagrams, however, learns that these diagrams give a reliable picture of the vegetation development in the northern Netherlands.

The zonation of FIRBAS (1949) as well as that of OVERBECK and SCHNEIDER (1938) are indicated on the left side of the diagrams. This does not mean that the present author always agrees with the dating of these zones. The zonation of OVERBECK and SCHNEIDER which has been established for north-west Germany and which, according to the investigations of SCHMITZ (1953), has shown its validity for Schleswig-Holstein can also easily be applied to Dutch diagrams. A third zonation applicable to Dutch diagrams is the one established for Danish diagrams by JESSEN (1934, 1938) and IVERSEN (1941).

In Table I a survey is given of the zonations mentioned above with a short characteristic of the pollen floristic zones. The correlation between the zonation of FIRBAS and that of OVERBECK and SCHNEIDER is not in agreement with that proposed by OVERBECK (1952). There is also a slight difference with the correlation WATERBOLK (1954*b*) gives. For the comparing of the zones VIII, IX and X of OVERBECK and SCHNEIDER with the zones VII and VIII of FIRBAS especially the behaviour of the curves for *Ulmus* and *Corylus* and the beginning of the curve for *Plantago lanceolata* were used.

TABLE I. Pollen analytical zonation of the late- and post-glacial time.

according to FIRBAS		according to OVERBECK and SCHNEIDER		according to JESSEN and IVERSEN	
X	Large-scale clearance of the forest. Increase of the NAP, especially of pollen of cultivation. *Alnus* often decreases, while *Quercus* shows an increase. In the upper part of this zone *Pinus* rises on account of the cultivation of the fir.		XII	IX	Subatlantic time
XI	Expansion of *Fagus*. *Carpinus* reaches relatively high values. *Corylus* shows relatively low percentages. *Tilia* no longer forms a continuous curve.		XI		
VIII	Increase of *Fagus*. *Carpinus* is present in low percentages. Decrease of *Corylus* in the upper part of this zone.	Fall of *Corylus*. Increase of *Fagus*.	X		
		Less *Ulmus* and *Tilia*. *Fagus* shows a continuous curve. Border with zone X: the last *Corylus* maximum (C_4).	IX	VIII	Subboreal time
VII	*Ulmus* and *Tilia* show a slight fall. *Fraxinus* increases. *Fagus* occurs regularly. First pollen of *Cerealia*. *Corylus* is abundant, with a maximum at the end of this zone. Border with zone VIII: decrease of *Tilia* and *Ulmus*.	*Ulmus* and *Tilia* reach relatively high values. *Fraxinus* appears. *Corylus* is abundant, and shows some maxima. *Alnus* and *Quercus* equally can reach high values. Appearance of *Plantago* and *Cerealia* in the upper part of this zone. Border with zone IX: the last *Corylus* maximum but one (C_3).	VIII	VII	Atlantic time
VI	*Quercus*, *Corylus* and *Alnus* reach high percentages. *Ulmus* and *Tilia* are relatively abundant. Border with zone VII: decrease of *Pinus*.				
V	*Pinus* is usually dominant, but *Betula* equally can show high values. *Corylus* shows a sharp rise, and reaches its first maximum in the second part of this zone. *Quercus* increases, whilst *Ulmus* also reaches a relatively high percentage. At the end of this zone *Tilia* and *Alnus* expand. Border with zone VI: sharp rise of *Alnus* and decrease of *Pinus* and *Corylus*.	Fir-hazel time. Characterized by a *Corylus* maximum (C_1). *Ulmus* and *Quercus* increase. *Tilia* and *Alnus* reach a continuous curve. Border with zone VIII: intersection of the curves for *Pinus* and *Alnus*.	VII	VI	Boreal time
		Fir time. *Pinus* is dominant. *Corylus* increases. *Quercus* and *Ulmus* are present, but not yet *Tilia* and *Alnus*. Border with zone VII: sharp rise in the *Corylus* curve.	VI	V	
IV	Final amelioration of climate. *Betula* is still dominant, but *Pinus* shows an increase. The NAP shows a sharp decline. *Corylus* appears, just as *Ulmus*. Border with the following zone: the beginning of the increase of *Corylus*.		V	IV	Preboreal time
III	A sharp rise of the NAP, and a decline of the AP, especially of *Pinus*.		IV	III	Late Dryas time
II	A sharp decline of all NAP. Rather dense forests. At first especially *Betula*, in the second phase of this period also much *Pinus*.		III	II	Allerød time
I*b*	First amelioration of climate. Decrease of the extremely high NAP, particularly of *Cyperaceae*. Increase of *Artemisia*, and appearance of *Plantago*, *Helianthemum* and others. *Betula* is present.		II	I	Older Dryas time
I*a*	Very high herbaceous percentages, especially of *Cyperaceae*. *Pinus* is relatively abundant on account of long distance transport.		I		

In addition the periods of BLYTT/SERNANDER are generally applied.

An investigation into the immigration of the present flora in Norway led BLYTT (1876) to accept a number of alternating rainy and dry periods since the retreat of the ice. The stratigraphy of the Norwegian raised bogs was considered by him as evidence for his theory. This theory which at first did not meet with much approval could in the main be confirmed by SERNANDER (1908, 1910) on the ground of his investigations into the stratigraphy of the Swedish bogs. After having undergone some alterations proposed by SERNANDER this theory concerning the sequence of climatic periods became generally accepted in Europe. The periods of BLYTT/SERNANDER are still fairly generally applied, although more recent stratigraphical and pollen analytical investigations have demonstrated that the climatological interpretation cannot be quite correct.

The beginning of the Preboreal time is generally placed at the beginning of the final amelioration of climate after the Late Dryas time. In the diagrams this is shown in a steep decline of the herbaceous pollen.

The Preboreal/Boreal transition coincides with the beginning of the first increase of *Corylus* (FIRBAS, 1949; OVERBECK and SCHNEIDER, 1938).

In western Europe the Boreal/Atlantic transition is generally placed at the level where the rising *Alnus* curve intersects the falling *Pinus* curve.

There is less general agreement with regard to the Atlantic/Subboreal transition. WEBER (1910, 1926, 1930) supposed that during the Subboreal time no peat formation took place, so that Subatlantic peat would rest directly on Atlantic peat which during the Subboreal time would have undergone a strong weathering. Later on, when it appeared that—at least in the large raised bogs—peat formation had not come to a standstill, the upper part of the highly humified *Sphagnum* peat which contains many remains of heather was supposed to have been formed during the Subboreal time. Pollen analytically the Subboreal time would be characterized by the presence of *Fagus* and high *Calluna* percentages.

In north-west Europe the Neolithic period would comprise the upper part of the Atlantic time, while the Bronze Age would coincide with the Subboreal time (SERNANDER, 1908; H. A. WEBER, 1918). As the chief argument for placing the Atlantic/Subboreal transition at the border between the Late Stone Age and the Bronze Age VAN GIFFEN (1941*b*, 1943, 1947) puts forward the phenomenon that on the higher sandy soils the subsoil of the Bronze Age and Iron Age barrows always shows a podzol profile. Below Neolithic tumuli, on the other hand, such a podzol profile never has been found. This difference in soil formation must, according to VAN GIFFEN, be the effect of a change of climate which would separate the Atlantic and Subboreal time.

This border between the Atlantic and Subboreal time is based, however, on stratigraphy and is pollen analytically not well defined. In Danish diagrams IVERSEN (1941) places the Atlantic/Subboreal transition at the level where the curves for *Hedera* and *Ulmus* show

a decline—a steep one for *Hedera*—and *Fraxinus* rises. According to IVERSEN the steep decline of *Hedera* must be effected by a change of climate, viz. a fall in winter temperatures which would be characteristic of the Subboreal time. Just above this transition the first pollen grains of *Plantago lanceolata* and *Cerealia* appear. The appearance of these pollen types points to the beginning of Neolithic agriculture. It must be noted that in this case—contrary to the original zonation—the Neolithic period covers the first part of the Subboreal time. This Atlantic/Subboreal transition of IVERSEN coincides with the zone border VII/VIII of JESSEN (1934, 1938) who places that border at the level where in his diagrams the curves for *Ulmus* and *Tilia* show a rather sharp decline.

In the English and Irish diagrams the transition VII*a* (Atlantic time)/VII*b* (Subboreal time) is placed at the fall of the *Ulmus* curve (GODWIN, 1943; JESSEN, 1949; MITCHELL, 1951). Here the first pollen grains of *Plantago lanceolata* and *Cerealia* appear likewise at the beginning of the Subboreal time.

In Drente WATERBOLK (1954*b*) found a decrease of *Ulmus* and *Tilia* accompanied by the beginning of the plantain curve.

FIRBAS (1949) places the beginning of the Subboreal time at the beginning of his zone VIII (beginning of the increase of *Fagus*, decrease of *Tilia* and *Ulmus*). This criterion for the Atlantic/Subboreal transition corresponds with that used by the authors mentioned above. The fact that, according to FIRBAS, in central Europe the first pollen grains of *Cerealia* already appear at the end of the Atlantic time would suggest that there agriculture was practised at an earlier time than in north-west Europe. This would be in agreement with the theories of the archaeologists. It must, however, be borne in mind that it is quite well possible that the decline of *Ulmus* is not a synchronous phenomenon in central and north-west Europe. This has to be investigated by means of radio-carbon dating.

OVERBECK (1952) leaves the exact position of the Atlantic/Subboreal transition undecided when he states that his zone IX belongs partly to the Atlantic, partly to the Subboreal time. In his preceding zone VIII, however, plantain already occurs regularly. Consequently his Atlantic/Subboreal transition cannot agree with that of the Danish investigators, not even if the whole zone IX is counted to the Subboreal time (SCHMITZ, 1953).

In the present paper the Atlantic/Subboreal transition is placed at the fall of *Tilia* and *Ulmus*.

As a transition from the Subboreal to the Subatlantic time the so-called *Grenzhorizont* of WEBER is still fairly generally used. As will be discussed in Chapter VI this *Grenzhorizont*, however, is not a synchronous phenomenon, and must on that account be abandoned as a zone border.

In the Danish diagrams JESSEN (1934, 1938), IVERSEN (1941) and MIKKELSEN (1949) place the Subboreal/Subatlantic transition at the level where *Fagus*—dependent on the type of soil—for the first time regularly occurs or shows its first increase. In the diagrams from

Danish *gyttja* deposits the curves for herbaceous pollen types rise markedly from that border onwards. This increase would be the effect of the interference of Early Iron Age people with the natural vegetation (IVERSEN, 1941; MIKKELSEN, 1949). As the increase of *Fagus* is also clearly shown in the diagrams from north-west Germany and the Netherlands the beginning of this increase can be used as a criterion for defining the Subboreal/Subatlantic transition.

Haule. On account of a prolonged drought during the autumn of 1951 a deep drainage trench exposing *gyttja* deposits in the south-eastern part of the province of Friesland did no longer contain water. It was clearly visible that the *gyttja* deposits do not extend over a long distance, but that these deposits always occur in basin-shaped depressions in the boulder clay. During the late-glacial time there must have been here a large number of fens.

The diagram of Fig. 3 is composed of the diagrams from two profiles. The distance between the two spots where the samples were collected is 2000 m. In one diagram the course of the late-glacial vegetation development with the exception of the earliest phases could be observed, whereas in the other diagram it was just these early phases which were represented. As it was quite possible to fit both diagrams together one diagram is composed. The place where the diagrams are fitted together is indicated by an interruption of the pollen lines.

The composition of this late-glacial diagram differs from that generally used for post-glacial diagrams. By this way of representing worked out by IVERSEN (1947) the course of the relation between tree and herbaceous pollen characteristic of the late-glacial time is clearly shown.

On the spots where the samples were collected the following profiles were recorded

I.	0– 63	cm	disturbed soil
	63– 68	,,	sandy peat
	68–105	,,	sandy clay *gyttja*
	105–115	,,	detritus *gyttja*
	115–120	,,	clay *gyttja*
	120–130	,,	detritus *gyttja*
	130–140	,,	clay *gyttja*
	140–145	,,	sandy clay *gyttja*
	145–	,,	sand
II.	0–160	,,	drift sand
	160–175	,,	sandy peat
	175–260	,,	sandy clay *gyttja*
	260–340	,,	alternating layers of sand and weathered boulder clay
	340–	,,	boulder clay

Emmererfscheidenveen. The raised bog near Emmererfscheidenveen forms part of the formerly extensive raised bog east of the chain of hills called Hondsrug. This raised bog lies in the initial valley of the Hunze. At the lowest parts peat formation already started in late-

glacial time. The natural drainage of this raised bog, which in the south-east joins the Bourtanger raised bog at both sides of the German-Dutch border, took place by a stream called Runde which is running in northern direction. For further details we may refer to VISSCHER (1931) who made a geographical study of this region.

The bogs east of the Hondsrug have vanished for the greater part in consequence of intensive peat-digging. As the peat is cut away in long strips a number of good sections can be observed, especially shortly after the peat-digging campaign. Everywhere the upper peat layer has vanished as during the last century, on behalf of the buck-wheat culture, the peat surface was set on fire every year.

At a site about 6 km east-north-east of Emmen and about 3 km south-west of Emmererfscheidenveen a complete profile was collected

0– 61	cm	fresh *Sphagnum imbricatum* peat
61– 66	,,	fresh *Sphagnum papillosum* peat
66– 90	,,	highly humified *Sphagnum* peat with remains of *Ericaceae* and *Eriophorum*
90–106	,,	fresh *Sphagnum cuspidatum* peat with remains of *Eriophorum* and leaves of *Andromeda*
106–115	,,	highly humified *Sphagnum* peat with remains of *Ericaceae*
115–145	,,	highly humified *Eriophorum* peat
145–191	,,	highly humified *Sphagnum* peat with remains of *Eriophorum* and *Ericaceae*
191–200	,,	moderately humified *Sphagnum cuspidatum* peat
200–270	,,	highly humified *Hypnum* peat
270–278	,,	moderately humified *Sphagnum rubellum* peat
278–300	,,	highly humified wood peat
300–329	,,	highly humified fen peat
329–330	,,	charcoal layer
330–334	,,	*gyttja*
334–342	,,	*Carex-Hypnum* peat
342–	,,	sand

The spectra of the lowest part of this profile, which is a late-glacial deposit, have not been published. Moreover, in consequence of a prehistoric fire there is a gap between the deposits below and above the charcoal layer, so that the earliest phases of the Boreal time are not represented.

Fochteloo. This profile containing a more complete Subatlantic part than the profile from south-east Drente was sampled on the territory of the peat-moss-litter factory between Veenhuizen and Fochteloo. This raised bog is situated at both sides of the border between the provinces of Friesland and Drente, at about 12 km west of Assen.

It is interesting to note that in some places where the peat had been removed the stumps could be observed of the trees constituting the forest that represented the natural vegetation before peat formation started. The effect of a rise in the ground water table was clearly visible. At a later stage the original oak forest was replaced by an *Alnetum*. The superficial root system of the alder trees points to a lack of oxygen on account of the high level of the ground water.

On the spot where the samples were collected the profile was as follows

0– 10	cm	disturbed peat
10– 20	,,	moderately to highly humified *Sphagnum imbricatum* and *palustre* peat with many *Monocotyledons* and some *Eriophorum*
20– 26	,,	moderately humified *Sphagnum imbricatum* and *palustre* peat with many *Monocotyledons* and *Eriophorum*
26– 37	,,	fresh *Sphagnum imbricatum* peat
37– 48	,,	fresh *Sphagnum cuspidatum* peat
48– 56	,,	moderately humified *Sphagnum imbricatum* peat with *Monocotyledons*, *Eriophorum* and some *Calluna*
56– 63	,,	highly humified *Sphagnum imbricatum* peat with *Monocotyledons*, *Eriophorum* and *Calluna*
63– 70	,,	moderately humified *Eriophorum* peat
70– 76	,,	moderately humified *Sphagnum palustre* and *imbricatum* peat
76– 82	,,	fresh *Sphagnum palustre* and *imbricatum* peat
82– 84	,,	moderately humified *Sphagnum palustre* and *imbricatum* peat
84– 90	,,	moderately humified *Sphagnum magellanicum* peat with *Monocotyledons*
90– 97	,,	moderately humified *Sphagnum imbricatum* peat with some *Eriophorum*
97–103	,,	rather fresh *Sphagnum imbricatum* peat
103–107	,,	fresh *Sphagnum imbricatum* peat with rhizomes of *Scheuchzeria*
107–111	,,	fresh *Sphagnum cuspidatum* peat
111–118	,,	highly humified *Eriophorum* peat
118–145	,,	highly humified peat with abundant remains of *Monocotyledons*
145–150	,,	humous sand

Discussion of the diagrams

Late-glacial time. It appears that the lower part of the Haule profile must still have been deposited in the so-called pleni-glacial time, *i.e.* in the last cold stage of the Würm glaciation, before the beginning of the late-glacial time. The relation between tree and herbaceous pollen in the lower part of the diagram points to a tree-less arctic vegetation. Moreover, in this part of the diagram *Pinus* is the main constituent of the tree pollen, while *Betula* pollen only occurs in very small numbers. Investigations of surface samples from the tundra region in north Finland by Aario (1940) have demonstrated that in those samples the pollen of *Pinus* is more abundant than that of *Betula*, although the distance from the tundra to the pine forests is greater than that from the tundra to the birch forests which form a belt between the tundra and the pine forests. Pollen analysis of surface samples from the tundra region by Van der Hammen (1951) led to the same result. The fact that many plants which occur regularly in the late-glacial time are lacking in the lowermost samples of the diagram is in accordance with the cold climate.

Van der Hammen (1951) considers the rise of the *Artemisia* curve as the first effect of the amelioration of climate, the beginning of late-glacial time. In the lowermost samples *Artemisia* shows very low percentages, while at a depth of 245 cm the pollen of this plant reaches a value of 1.5 %. This increase of *Artemisia* is accompanied by a decrease in the extremely high herbaceous percentages of the pleni-glacial time.

During the Older Dryas time (zone II according to Overbeck and Schneider, zone I*b* according to Firbas) the herbaceous percentages remain high, while *Betula* is now the main contributor of tree pollen. The relatively high values for *Artemisia*, *Juniperus*, *Plantago*,

Helianthemum, *Rumex* and *Thalictrum* and the very low *Ericaceae* percentages are characteristic of this period.

The Older Dryas time can be subdivided into an Earliest and Earlier Dryas time, separated by a small oscillation of climate, the so-called Bølling oscillation. Although at a depth of 145 cm the tree pollen shows a slight maximum, which could represent the Bølling oscillation, this subdivision of the Older Dryas time is not applied here.

Some special attention must be paid to the occurrence of a pollen grain of *Polemonium coeruleum* in the not published part of the lower diagram which belongs to the Older Dryas time. Up to now this pollen grain which can easily be recognized has not been mentioned for the late-glacial time of the Netherlands. Godwin (1950) and Schmitz (1953) report the occurrence of this pollen in late-glacial deposits of England and north Germany respectively.

The Allerød time (zone III according to Overbeck and Schneider, zone II according to Firbas) is characterized by a steep decline in *Gramineae*, *Cyperaceae* and other herbs. The forest, at first a birch forest and in the second part of this period a mixed pine-birch forest, must have been rather dense. The presence of small pieces of *Pinus* charcoal in the so-called Allerød layer in the coversand deposits is in agreement with the fairly high *Pinus* percentages in the second part of the Allerød time.

In the Late Dryas time (zone IV according to Overbeck and Schneider, zone III according to Firbas) herbaceous pollen again reaches fairly high values. In contrast with the other diagrams from the northern Netherlands published up to now, viz. Hijkermeer (Van der Hammen, 1949), Mekelermeer (Van der Hammen, 1951) and a late-glacial deposit near Opeinde (De Planque, 1950), in the Haule diagram pollen of *Ericales* is not abundant. *Empetrum* hardly exceeds 2 %, whereas in the diagrams mentioned above *Empetrum* reaches values of 25 to 30 %. The low values for *Empetrum* in the Haule diagram suggest that in the Late Dryas time the *Empetrum* vegetations must have had a local character in the northern Netherlands. The increase of *Sphagnum* spores begins in the upper part of the Allerød time, and during the Late Dryas time the *Sphagnum* percentages remain high. According to Van der Hammen (1951) the expansion of *Empetrum* and *Sphagnum* indicates a more oceanic character of the climate.

The pollen grains of thermophilous trees which were rather regularly found must partly be of secondary origin—which in view of the character of the deposits is quite well possible—partly be the effect of a long distance transport. For Aario (1940) mentions that in the surface samples from the tundra region near Petsamo pollen grains of *Picea* and *Alnus* occur. This occurrence must be ascribed to a long distance transport. On that account it is not unlikely that the pollen grains of *Alnus* and *Picea* found in the Haule deposits were dispersed by trees of a river-bound forest at a distance of some hundreds of kilometers.

Post-glacial time. The first part of the post-glacial time is still represented

in the Haule diagram. The beginning of the post-glacial time is placed at the beginning of the final amelioration of climate which in the first place effected an increase of tree pollen and a corresponding decrease of herbaceous pollen. In the Haule diagram the Preboreal time begins at a depth of 90 cm. The appearance of thermophilous trees in the northern Netherlands did not take place until the end of the Preboreal time when *Ulmus* and *Corylus* immigrate. At the end of the Preboreal time the *Pinus* curve shows a steep increase.

Just above a depth of 70 cm the first part of the Boreal time begins. The herbaceous percentage is very low, *Pinus* pollen is dominant and the *Corylus* curve shows a beginning of increase. Of the other thermophilous trees only *Ulmus* is present. *Quercus*, *Alnus*, *Tilia* and *Fraxinus* will appear later on.

The further course of the vegetation development can be followed in the Emmererfscheidenveen diagram (Fig. 4) which fits rather well with the Haule diagram.

A small number of diagrams from the region of south-east Drente has already been published, viz. three diagrams in the vicinity of Zwartemeer (Van Raalte and Wassink, 1932), one diagram near Valthermond (Van Dobben, 1932) and one near Roswinkel (Florschütz and Wassink, 1935). As the intervals between the analysed samples are too great these diagrams only give a rather rough picture of the vegetation development of the region.

As already mentioned Visscher (1931) made a geographical study of this region. It is to be regretted that he did not complete his detailed stratigraphical investigation with a pollen analytical investigation of some profiles. In that case some incorrect conclusions, which for the rest he mentions again in a later paper (Visscher, 1949), could have been avoided. It appears that the so-called middle layer of tree stumps—on top of the fen peat—was not formed in the "very dry and warm" Boreal time, but as late as the Atlantic time.

As in the diagrams already published from this region (Van Raalte and Wassink, 1932; Van Dobben, 1932) the Boreal *Corylus* maximum is not high. The behaviour of the *Pinus* curve caused some difficulties. From a depth of 310 cm the *Pinus* curve shows a steep decline in order to reach a value below that of *Alnus* at a depth of 300 cm. Somewhat upwards, however, *Pinus* reaches again a fairly high percentage, and between 285 and 290 cm the rising *Alnus* line intersects the—now final—falling *Pinus* line for the second time. The question arose where the Boreal/Atlantic transition has to be placed. On account of the alternating dominance of *Pinus* and *Betula* in the lower part of the diagram it is not possible to determine the correct position of the Boreal/Atlantic transition. For that reason the lower part of a second profile from the same raised bog was analysed (Emmererfscheidenveen II, Fig. 5).

This profile was already sampled in 1938 on the occasion of the discovery of a peat burial. As the peat monolith was dried up it was not possible to give a somewhat accurate stratigraphy.

Although in the Boreal part of this diagram there are also alternating high *Pinus* and *Betula* percentages it is yet clear that the Boreal/

Atlantic transition must be placed at a depth of about 260 cm, where the rising *Alnus* curve intersects the falling curves for *Pinus* and *Betula*. By comparison of the curves for *Tilia* and *Fraxinus* in both diagrams it is clear that in the diagram of Fig. 4 the Boreal/Atlantic transition lies between 285 and 289 cm. At the end of the Boreal time the *Fraxinus* curve rises quickly to a value of 2–4 % at the beginning of the Atlantic time, whilst the increase of *Tilia* comes to an end at the Boreal/Atlantic transition.

The occurrence of high *Betula* percentages in Boreal and early Atlantic time can also be seen in other diagrams from the northern Netherlands (*cf.* Hoornder Veen, Eshuis, 1936; Princehof A, Van Zeist, 1950), and must be the effect of local production of birch pollen.

At the beginning of the Atlantic time, at a depth of 275 cm, there is a rather low *Corylus* maximum which corresponds with the C_2 of Overbeck and Schneider (1938). Concerning the behaviour of the other curves in the left part of the diagram it can be noted that *Quercus* does not reach an average value of 20 % until a depth of about 260 cm, and that the *Alnus* percentages—compared with those in the later phases of the post-glacial time—are rather low. During the Atlantic time the mixed deciduous forest, the composition of which will have varied dependent on edaphic factors, was the dominant vegetation type, whereas the share of the *Alneta* was relatively small.

The occurrence of a few pollen grains of *Viscum* must be noted. As the factors for a wide distribution of the pollen of this semi-parasite are not favourable it is not surprising that *Viscum* pollen is very rare in deposits of large raised bogs.

In most sections of the raised bog from south-east Drente a conspicuous *Scheuchzeria* layer with numerous stumps of *Pinus* and *Betula* can be located. This layer, which forms the transition from the fen peat to the *Sphagnum* peat and which locally can be lacking, was not present on the spot where the samples for the Emmererfscheidenveen I diagram were collected. For this reason a separate diagram was prepared from samples collected on a spot with a well developed *Scheuchzeria* layer (Emmererfscheidenveen III, Fig. 6). The *Scheuchzeria* layer contained large amounts of *Betula* pollen, whereas the *Pinus* percentages are not higher than those in the samples below and above that layer. It is highly probable that on the spot in question birch was the dominant tree. When we compare both diagrams it becomes clear that the *Pinus* maximum between 204 and 210 cm in the diagram of Fig. 4 corresponds with the layer of tree stumps. There is a close correspondence between the spectra from 215 to 230 cm in the small diagram and the spectra from 220 to 235 cm in the Emmererfscheidenveen I diagram, while the spectrum at a depth of 190 cm, above the *Scheuchzeria* layer, corresponds with the spectrum at a depth of 179 cm in the diagram of Fig. 4.

Concerning the Emmererfscheidenveen III diagram the relatively high percentage of *Nymphaea* in the lowermost spectrum has to be mentioned.

Although in a very low percentage (0.2 %) *Fagus* was already found rather regularly in the upper part of the Atlantic time. It is not probable, however, that during that time this tree already formed part of the vegetation of the northern Netherlands. The regular occurrence of *Fagus* pollen suggests that the beech will have occurred not too far from this region. Pollen of *Picea* and *Acer* which will never

have formed part of the natural vegetation of this area were found from the beginning of the Atlantic time. Scattered *Humulus* pollen was found throughout the whole profile.

Concerning the herbaceous pollen special attention must be paid to the *Rumex* curve which shows the highest percentages in the Atlantic part of the diagram. In general the regular occurrence of pollen of this plant is regarded as evidence of human activity. Although in post-glacial *gyttja* deposits relatively high *Rumex* percentages undoubtedly will be due to human influence on the vegetation this is not always true of bog deposits as *Rumex* can form part of the bog vegetation.

In the *Ulmus* curve four maxima can be distinguished, viz. at a depth of 305, 260, 205 and 170 cm. In many diagrams from Ostfriesland (north-west Germany) the *Ulmus* curve shows also four maxima (GROHNE, oral communication), so that this phenomenon probably is not only of local importance. Just above the last *Ulmus* maximum the Atlantic/Subboreal transition is placed. At the same time the *Tilia* curve shows a decline, whilst *Plantago lanceolata* suddenly appears. As has been stated on p. 9 these features are regarded as a reliable criterion for defining the Atlantic/Subboreal transition. It is not quite clear whether the few pollen grains of *Plantago lanceolata* which were found below a depth of 165 cm must be ascribed to human (Mesolithic?) activity or that *Plantago lanceolata* already occurred here before the immigration of Neolithic man. According to IVERSEN (1949) this plant did not grow in Denmark before the beginning of Neolithic agriculture. As has already been noted by WATERBOLK (1954*b*) the decline in the *Ulmus* curve is—in contrast with Danish diagrams—not accompanied by an increase of *Fraxinus* which already in Atlantic time shows relatively high values in Dutch diagrams. The sharp decline of *Hedera*, which is a characteristic feature in Danish diagrams, cannot be observed in the diagrams from the northern Netherlands as the *Hedera* values in the first part of the Subboreal time do not differ from those in the Atlantic time. A marked decrease of *Hedera* takes place in the upper part of the Subboreal time, and in Subatlantic time this liane virtually disappears altogether.

The *Corylus* maximum at a depth of 160 cm can be compared with the $C_\times$ of OVERBECK (1952) which in all diagrams from the raised bog near Gifhorn coincides with the beginning of the *Plantago* curve. The *Corylus* maximum at a depth of 125 cm corresponds with the C_3 of OVERBECK and SCHNEIDER (1938). The *Fagus* percentages show a slight increase at a depth of 100 cm. This first—although very small—increase of *Fagus* is typical of the diagrams from south-east Drente, and corresponds with a similar increase—in most cases the beginning of the continuous *Fagus* curve—in the diagrams from north-west Germany. This increase of *Fagus* pollen points to the appearance of *Fagus* in the northern Netherlands. A second more important increase of *Fagus* pollen starts at a depth of 85 cm. This last increase of *Fagus* is accompanied by the final decline of *Corylus* after the last *Corylus* maximum (C_4 of OVERBECK and SCHNEIDER, 1938) at a depth of 85 cm. In all diagrams from south-east Drente

the beginning of the expansion of *Fagus* coincides with the beginning of the decline of *Corylus*. This is also true for most diagrams from north-west Germany, while in the diagrams from the Peel bogs (southern Netherlands) the same behaviour of the curves for *Fagus* and *Corylus* can be observed (Eshuis, 1946). At a depth of 60 cm *Fagus* attains a value of about 5 %. In nearly all diagrams from south-east Drente the end of the second increase of *Fagus* is accompanied by a *Fraxinus* maximum. As most diagrams from the northern Netherlands and north-west Germany do not show a *Fraxinus* curve it is not yet possible to examine whether this is only a local phenomenon or not. In this connection it is worth mentioning that in the Fochteloo diagram (Fig. 7) there is also a *Fraxinus* maximum at the level where *Fagus* reaches a value of about 5 %.

From the level where *Fagus* begins its expansion *Carpinus* shows a continuous curve. Although in the corresponding part of the other diagrams from this region the *Carpinus* curve is not always a continuous one, yet it can be generally stated that the first important increase of *Fagus* is accompanied by a regular occurrence of *Carpinus*. An increase in the *Carpinus* curve, which is likewise characteristic of all diagrams from the northern Netherlands and north-west Germany, can be seen at a depth of 25 cm.

Alnus shows high percentages in the upper part of the diagram. In consequence of the gradual decrease of the forest cover on the higher sandy soils the *Alneta*, which not until later will be cleared, are relatively on the increase. The fairly high values for *Plantago lanceolata* and *Artemisia* and the regular occurrence of *Urtica*, *Plantago major* and *Cerealia* in the upper part of the diagram also indicate an increasing human activity.

On pp. 9–10 the Subboreal/Subatlantic transition has already been discussed. In agreement with Danish investigators this transition is placed here at the beginning of the first important increase of *Fagus*. As in nearly all diagrams from north-west Germany the beginning of this increase coincides with the last *Corylus* maximum (C_4 of Overbeck and Schneider, 1938) this pollen analytical criterion is well suited to define the transition from Subboreal to Subatlantic time. This in order to substitute the so-called *Grenzhorizont* of Weber which—as will be demonstrated in Chapter VI—is not a synchronous phenomenon, and which on that account cannot be used as zone border. In north-west Europe the criterion mentioned above approximately coincides with the transition from Bronze Age to Iron Age (*cf.* Chapter IV) which can be dated at about 500 B.C. Consequently the dating of this pollen analytically defined zone border is in agreement with the general view to let Subatlantic time start at about 500 B.C.

In the Emmererfscheidenveen I diagram the vegetation development is represented up to some centuries A.D. as in consequence of buckwheat cultures the upper part of the peat has vanished.

The course of the curves in the lower part of the Fochteloo diagram (Fig. 7) is not quite clear. It is not possible to decide whether the last *Corylus* maximum (C_4) must be placed below the lowermost spectrum or that the spectrum at a

depth of 137 cm shows this maximum, and that in consequence of local circumstances the *Corylus* percentages are too low. At any rate it is certain that the spectrum at a depth of 132 cm corresponds with that at a depth of 59 cm in the diagram from Emmererfscheidenveen (*Fagus* reaches a value of about 5 %, *Fraxinus* maximum). More upwards the curves show a close correspondence with those of the Emmererfscheidenveen diagram. The high *Myrica* percentages deserve some special attention. These prove once more to be suspicious of unexpected and very high "*Corylus*" percentages.

From a depth of about 110 cm the curves in the left part of the Fochteloo diagram (Fig. 7) do not longer show important alterations with the exception of the *Alnus* curve which gradually falls in the upper part of the diagram. The curves for *Fagus* and *Carpinus*, however, show some characteristic features. The first increase of *Carpinus*, which in the Fochteloo diagram takes place at a depth of 95 cm, is also present in the Emmererfscheidenveen diagram. At about the same time the continuous *Tilia* curve comes to an end. For the present the *Carpinus* percentages fluctuate between 0.5 and 2 %, while *Fagus* maintains a value of about 4 %. In the upper part of the Emmererfscheidenveen diagram there is a crest of nearly 9 % in the *Fagus* curve. It is not impossible that with a shorter distance between the analysed samples in the Fochteloo diagram also one or more incidentally high *Fagus* percentages would have been found. A second increase of *Carpinus* starts at a depth of 55 cm in order to reach values of more than 5 % in the upper part of the diagram. The *Fagus* percentages which are less regular than those of *Carpinus* also show an—on an average—important increase. In the upper part of the diagram the values for *Fagus* and *Carpinus* remain relatively high.

On account of the generally too great intervals between the spectra and the small number of pollen counted in each sample this course of the curves for *Fagus* and *Carpinus* is not very clear in the other diagrams from the northern Netherlands. The behaviour of the curves for *Fagus* and *Carpinus* in the diagrams Paterswal 2 and Engbertsdijk (eastern Netherlands) corresponds rather well with that in the Fochteloo diagram (Florschütz and Wassink, 1935). More to the east, in north-west Germany, where *Fagus* and *Carpinus* reach higher values, the curves for both trees show essentially the same aspect. Consequently these diagrams can be very well compared with the diagram from Fochteloo as far as the Subatlantic time is concerned. In the Wakenitz diagram near Lübeck (Schmitz, 1951) this course of the curves for *Fagus* and *Carpinus* can also be noticed. The behaviour of *Fagus* and *Carpinus* in Denmark agrees very well with that in the northern Netherlands, on the understanding that on the fertile soils of the Danish islands *Fagus* and *Carpinus* were more numerous than in Drente (Mikkelsen, 1949).

The gradual decrease of *Alnus* in the upper part of the diagram must be ascribed to the cutting down of the *Alneta* along the streams and on other low lying sites. The marked increase of *Gramineae*, *Cerealia*, *Chenopodiaceae*, *Rumex* and *Plantago* in the upper part of the diagram also points to an increase of the cultivated area.

It is not possible to determine exactly till what time the vegetation

development can be followed in this diagram. As the *Pinus* percentages in the upper part of the diagram remain low it is certain that the time in which man changed the character of the forests by means of the laying-out of *Pinus* plantations is not represented.

As already has been noted at the beginning of this chapter the zonation of OVERBECK and SCHNEIDER (1938) can be very well applied to diagrams from the northern Netherlands. Zone I, the tree-less tundra time, covers the three spectra at the bottom of the Haule diagram. At a depth of 247 cm zone II begins with the increase of *Artemisia*. This zone in which the herbaceous percentages are not as high as in zone I ends at a depth of 135 cm where the sharp decline in herbaceous pollen starts. In this zone *Betula* pollen shows an important increase, whilst *Pinus* reaches fairly high values in the second part of zone III. The III/IV transition can be placed at a depth of 112 cm. Zone IV is characterized by rather high herbaceous percentages and a decrease of tree pollen. At a depth of 95 cm zone V begins which shows a decrease in the herbaceous percentages. At first *Betula* is dominant, whereas *Pinus* shows high values in the upper part of this zone. At the end of zone V the first thermophilous trees, viz. *Ulmus* and *Corylus*, appear. The zone border V/VI lies at a depth of 67 cm where the *Corylus* curve begins to rise. In zone VI *Tilia* and *Quercus* appear, while in the Emmererfscheidenveen diagram also *Alnus* was met with. Zone VII begins at a depth of 325 cm where *Corylus* rises quickly to the first maximum (C_1) which characterizes this zone. In the second part of zone VII *Alnus* increases, while *Fraxinus* appears at the end of this zone. As already has been discussed on p. 15 the Boreal/Atlantic transition which coincides with the zone border VII/VIII has to be placed at a depth of about 287 cm. The *Corylus* maximum (C_2) at a depth of 275 cm is characteristic of the lower part of zone VIII. The border between the subzones *a* and *b* lies at a depth of 230 cm where the *Pinus* curve falls to rather low values (5–10 %). Zone VIII ends at the *Corylus* maximum (C_3) at a depth of 135 cm. In the upper part of zone VIII*b* pollen of *Plantago lanceolata* shows a continuous curve. Zone IX ranges from the C_3 to the C_4 at a depth of 85 cm. Zone X is characterized by a decrease of *Corylus* and an increase of *Fagus*. The X/XI transition is placed at a depth of 60 cm where the decrease of *Corylus* comes to an end and *Fagus* reaches a relatively high value. As OVERBECK and SCHNEIDER (1938) used the *Grenzhorizont* of WEBER as the border between their zones X and XI they did not give a well defined pollen analytical criterion for this border. In the upper part of the Fochteloo diagram at a depth of 30 cm, where the herbaceous percentages show a marked increase the zone border XI/XII is placed.

The zonation according to FIRBAS agrees with that according to OVERBECK and SCHNEIDER as far as the late-glacial period is concerned. There is only a slight difference in numbering. Zone V comprises the zones VI and VII of OVERBECK and SCHNEIDER. The VI/VII transition lies at a depth of 230 cm where the *Pinus* curve

drops to a value of 5–10 %. The transition from zone VII to VIII has to be placed at the decrease of *Tilia* and *Ulmus* at a depth of 160 cm. As, according to FIRBAS, in north Germany the end of the decrease of *Corylus* can be used as a criterion for defining the VIII/IX transition this border is placed at a depth of 60 cm. The zone border IX/X coincides with the zone border XI/XII according to OVERBECK and SCHNEIDER and is consequently placed at a depth of 30 cm in the Fochteloo diagram.

IV. THE ARCHAEOLOGICAL DATING OF THE POLLEN DIAGRAM

This chapter will discuss the pollen analytical investigation of a number of archaeological objects found in bogs from north-west Europe. Among these finds there are two which have not yet been published, whilst one find, the bronze find of Roswinkel, was re-examined. This archaeological dating is not intended as a means to arrive at an absolute dating of the pollen diagram. Therefore the data are, as a rule, not sufficiently accurate, and there is not infrequently too much difference of opinion concerning the absolute age of the archaeological objects. Moreover, a ^{14}C-dating will give more accurate and more reliable results. The main purpose of this archaeological dating of the pollen diagram is to examine in what part of the diagram the Late Stone Age, the Bronze Age and the Iron Age have to be placed. In this way a comparison is possible of the results of the palynological investigation of peat samples and those of sand samples from barrows etc. As no sand samples older than Neolithic time were investigated this discussion will be confined to finds from the Late Stone Age, the Bronze Age and the Iron Age.

NEOLITHIC

Although in Drente various stone axes were found in the peat no single one hitherto appeared to be suitable for a pollen analytical investigation. The object had always been carefully cleaned, and, moreover, its position in the peat could not be established, because sometimes years elapsed before the find came into the hands of archaeologists. [1]

To a few Neolithic settlements which lay buried in the peat or which could be followed in the peat pollen analysis has been applied.

A Neolithic settlement near Hekelingen, west of Rotterdam (western Netherlands) was recently excavated (MODDERMAN, 1953). This settlement which lay on the bank of a river was overgrown by peat. Moreover, it was possible to follow the culture layer in the peat deposits behind the bank. Unfortunately the diagrams published by

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[1] VAN GIFFEN (1925) mentions the presence of about 170 archaeological objects found in the raised bogs from Drente. With the exception of a few peat burials to which still peat is adhering, the bronze find of Roswinkel is the only one which is still suitable for a pollen analytical investigation.

Florschütz (1953) cannot be compared with those from the northern Netherlands.

Jessen (1938) carried out a pollen analytical investigation of a culture layer which is ascribed to the Older Passage Grave period on the isle of Langeland. This culture layer was situated near the Gamellung bog in which it could be followed in the form of scattered bones of domestic animals, worked pieces of wood, sling stones and such like. Now it appears that in the pollen diagram this culture layer lies at a short distance above the decline of *Ulmus* and *Tilia*. This is in perfect agreement with Iversen (1941, 1949) who, on the ground of the sudden appearance of *Plantago lanceolata* and an increase of other weeds, arrived at the conclusion that in Denmark the beginning of the Neolithic period would correspond with the level immediately above the decrease of *Ulmus*.

A culture layer from the Younger Passage Grave period in Bundsö on the isle of Als appeared to lie at about 75 cm above the decline of *Ulmus* and *Tilia* (Jessen, 1938). It is not possible, however, to transfer accurately the spectrum which corresponds with the culture layer to the diagrams from north-west Germany and the northern Netherlands.

Another Neolithic settlement to which pollen analysis has been applied is that near the Dümmersee. On the border of this formerly rather extensive lake a settlement from the Passage Grave culture was excavated (Reinerth, 1939). On top of the culture layer which rested on peat, *gyttja* was deposited. The diagram Pfaffenberg prepared from a Dümmersee profile was published by Firbas (1949, Fig. 110*a*). At about 20 cm below the bottom of the culture layer the diagram shows a marked decrease of *Tilia* and *Ulmus*. Concerning the further interpretation of this diagram the following remarks can be made. The fact that the *Fagus* percentages remain low in the diagram (5 %) must, according to Pfaffenberg (in Firbas, 1949), be ascribed to the circumstance that in this region the soil is not favourable to beech. It is not unlikely, however, that this diagram is not complete, and that the greater part of the Subatlantic time is lacking, the more so as also *Carpinus* occurs only in very low percentages in the upper part of the diagram. The *Corylus* maximum in the upper part of the culture layer corresponds very probably with the C_3 of Overbeck and Schneider (1938), whilst the first increase of *Fagus* takes place just above the culture layer. In many diagrams from north-west Germany and the Netherlands *Fagus* shows its first—although slight—increase not far above the C_3. If this interpretation, which differs somewhat from the zoning that Firbas placed besides the Dümmersee diagram, is correct the pollen analytical position of this culture layer agrees with that of the other Neolithic finds.

Schubert (1933) carried out the pollen analytical investigation of the flint dagger of Iselersheim. Not until 8 years after the discovery a profile was sampled in the vicinity of the find-spot. The accurate position of the dagger in the peat could, however, no longer be verified. The pollen analytical result that the flint dagger has to be

placed in that part of the diagram in which *Fagus* does not yet show a countinuous curve agrees with the position of the Neolithic settlements discussed above. This investigation does not, however, permit further conclusions.

The same holds for the pollen analytical examination of the flint dagger from Wiepenkathen (BERTSCH in CASSAU, 1935). Although all conditions for a reliable palynological investigation of this unique find were present, the result is rather disappointing on account of the excessive intervals between the spectra and too small a number of pollen grains counted in each sample. It can only be stated that the find level lies rather far below the appearance of *Fagus* in this diagram.

The examination of the stone axe from the Passage Grave period found in the "Oyter Moor" near Bremen has not yet been published (*cf.* OVERBECK and SCHNEIDER, 1938).

JONASSEN (1950) investigated a stone axe from the Passage Grave period discovered *in situ* during the cleaning up of a peat wall in the Høgild bog on behalf of a stratigraphical examination. It appears that the find level has to be placed below the appearance of *Fagus*. It is not possible, however, to fit accurately the position of this stone axe into diagrams from north-west Germany.

EARLY BRONZE AGE

The bronze find of Roswinkel. In October 1924 a number of objects, viz. a ball of wool, some pieces of woollen fabric, a remnant of a hair comb, a small piece of leather, a fragment of a bronze palstave and a string of amber beads, were discovered in the "Roswinkeler Veen" near Oude Schutting. These objects, which are shown in the "Provinciaal Museum van Drente" at Assen, are said to have been found together (VAN GIFFEN, 1947, Plate 76). The fragment of the bronze palstave gives an archaeological dating to this find, namely Early Bronze Age, MONTELIUS II (VAN GIFFEN, 1930, pp. 79–80). It is a fortunate circumstance that the ball of wool has been preserved with its surrounding peat, whilst a second sod of peat shows the casts of two amber beads and a piece of woollen fabric. On that account a palynological examination of this find is still possible. Such an investigation was already carried out by FLORSCHÜTZ and WASSINK (1935). The latter were able to transfer the diagram prepared from the sod of peat with the ball of wool to the diagram from a profile which in 1930 was sampled in the vicinity of the find-spot. On the ground of this examination FLORSCHÜTZ and WASSINK arrived at the conclusion that the final fall of *Corylus* and the beginning of the *Fagus* curve have to be dated at about 1500 B.C.

As it is not well possible to transfer the results of FLORSCHÜTZ and WASSINK to the diagram from Emmererfscheidenveen a new pollen analytical investigation appeared necessary. For that purpose the two sods mentioned above were analysed without intervals ("*Lupendiagramm*"). Besides, it was necessary to prepare a diagram to which the diagrams from the sods could be transferred. Unfortunately the peat

in the immediate vicinity of the find-spot had been cut away. At a distance of 500–750 m from the find-spot a strip of peat was still present. The upper part of the profile, which in connection with this find is of importance, was sampled.

At this site the profile was as follows

0– 20	cm	moderately humified *Sphagnum* peat with many roots of *Molinia* covering the bog surface
20– 39	,,	fresh *Sphagnum imbricatum* peat
39– 44	,,	rather fresh *Sphagnum cuspidatum* peat with some roots of *Monocotyledons* and leaves of *Andromeda*
44– 98	,,	highly humified *Sphagnum rubellum* and *cf. palustre* peat with remains of *Eriophorum* and *Calluna*
98–103	,,	moderately humified *Sphagnum cuspidatum* peat
103–114	,,	highly humified *Sphagnum* peat with remains of *Calluna* and *Eriophorum*
114–143	,,	highly humified *Sphagnum* peat with remains of *Monocotyledons*, especially *Eriophorum*, and *Calluna*

The distance between the analysed samples is, as a rule, 5 cm. In that part of the diagram to which the diagrams from both sods of peat had to be transferred, a sample distance of 2.5 cm appeared necessary. In the intermediate samples a number of 500 AP was usually counted, which number was raised to 1000 wherever this was desirable.

The diagram from Roswinkel (Fig. 8) agrees fairly well with that from Emmererfscheidenveen which lies at a distance of about 6 km. The first characteristic point is the *Corylus* maximum (C_3) at a depth of 115 cm. The following sharp decline of *Corylus* and the *Quercus* maximum are also present in the Emmererfscheidenveen diagram. The *Fagus* values between 104.5 and 109.5 cm are—compared with those in the corresponding part of other diagrams—relatively high (0.5–0.8 %), which may perhaps be due to the local occurrence of one or a few trees. In this part of the diagram the *Betula* percentages are higher than those in the diagram from Emmererfscheidenveen. It is clear that the spectrum at a depth of 97 cm corresponds with that at a depth of 105 cm in the diagram from Emmererfscheidenveen: *Alnus* minimum, *Quercus* maximum, the spectrum preceding to the first increase of *Fagus*. The last *Corylus* maximum (C_4) after which *Corylus* falls to a value of about 10 %, is present at a depth of 67 cm. Just as in the other diagrams from south-east Drente the fall of *Corylus* is accompanied by the second more important increase in the Fagus curve, while here also the end of this increase of *Fagus* is coupled with a *Fraxinus* maximum.

The layer between 67 and 92 cm is much thicker than the corresponding layer in the profile from Emmererfscheidenveen. Moreover, the behaviour of the *Corylus* curve differs from that in the Emmererfscheidenveen diagram, and is more in agreement with that in the diagram from Bargeroosterveld (Fig. 9) which will be discussed on p. 26. From the *Corylus* minimum at a depth of 92 cm, which corresponds with the minimum at a depth of 95 cm in the diagram from Emmererfscheidenveen, *Corylus* does not rise right away to the last *Corylus* maximum (C_4) as in the Emmererfscheidenveen diagram.

At a depth of 79.5 cm the *Corylus* curve shows a new peak in order to reach the last maximum via a minimum at a depth of 74.5 cm. The *Corylus* curve thus shows some marked fluctuations between the C_3 and the C_4. As in the corresponding part of other diagrams from the raised bog of south-east Drente the *Corylus* curve shows similar fluctuations the behaviour of the *Corylus* curve in the diagram from Roswinkel can be considered as the normal one.

Summarizing it can thus be stated that the Roswinkel diagram agrees well with the other diagrams from south-east Drente. There is also a fairly good agreement with the diagram published by Florschütz and Wassink (1935). It appears, however, that in the last diagram the upper *Corylus* maximum does not correspond with the C_4, but with the C_3.

Proceeding now to a discussion of the analysis of both sods of peat difficulties arise. Although all objects would have been found together (Van Giffen, 1947, Plate 76) the structure of the peat of both sods shows a marked difference. The peat surrounding the ball of wool has a rather loose structure with many stems of *Calluna*, whereas the other sod of peat is more compact without macroscopic remains of *Ericaceae*. In both cases we have highly to rather highly humified *Sphagnum* peat. In addition to this difference in structure the diagrams from both sods do not agree (Fig. 8 A and B). [1] The diagram with the casts of amber beads is quite uniform with high *Alnus* percentages (50 %) and also high values for *Corylus* (28–35 %). The diagram of the other sod of peat shows more variation. This last diagram can easily be transferred to the diagram from Roswinkel: The spectrum No 4 corresponds with that at a depth of 67 cm in the Roswinkel diagram, viz. the last *Corylus* maximum and the beginning of the second increase of *Fagus*. The spectrum at a depth of 64.5 cm corresponds with the average of the samples 1 and 2. It is less clear how the samples 5–8 can be transferred, but it is fairly certain that the spectrum of sample 6 corresponds with that at a depth of 74.5 cm in the Roswinkel diagram. In that case peat formation at the site of the Roswinkel profile must—at least during the time in question—have been more rapid than at the site where the ball of wool was discovered. The find level of the ball of wool then corresponds with a depth of about 75 cm in the diagram from Roswinkel. The possibility remains that the find level lies somewhat higher if the equalization of sample 6 with the spectrum at a depth of 74.5 cm would not be correct. As it is certain, however, that the samples 1–4 correspond with that part of the diagram that lies between 64 and 67 cm the upper limit of this find level cannot be higher than 70 cm.

In the diagram from Roswinkel there is only one spectrum which bears sufficient resemblance to the very uniform diagram from the sod with the casts of amber beads, namely the spectrum at a depth of 87 cm. The high *Alnus* percentage, just as the values for *Corylus*,

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[1] As both sods of peat were analysed without intervals the vertical scale of both small diagrams does not agree with that of the diagram from Roswinkel.

Betula, *Pinus* and *Quercus* are of excellent agreement, whilst the percentages of the other trees do not vary considerably.

Concomitant with the fact that the peat of both sods shows a different structure, the find levels of the ball of wool and the amber beads appear not to coincide. Although the distance between the spectra corresponding with the find levels of the objects of both sods is not great (min. 12.5 cm, max. 17.5 cm) it cannot be neglected, the more so as 12.5 to 17.5 cm highly humified *Sphagnum* peat represents a not unimportant course of time.

As this examination led to a contradictory result the question arose what mistake had been made. In the report of a lecture which was read half a year after the discovery of the find, VAN GIFFEN (1925) did not mention the ball of wool at the enumeration of the objects of the bronze find of Roswinkel, nor is this ball of wool reported in a later enumeration (VAN GIFFEN, 1930, pp. 79–80). The fact that on the 1 : 50000 ordnance map in the archives of the Institute for Biological Archaeology two marks representing points at a mutual distance of 350 m have been placed at the site in question, suggests that the ball of wool was found at some distance from the find-spot of the other objects. Moreover, according to VAN GIFFEN (oral communication) it is quite certain that the amber beads and the fragment of the bronze palstave were found together. On that account it is certainly justified to place the archaeological dating MONTELIUS II at a depth of 87 cm, that is 5 cm above the *Corylus* minimum which is present in all diagrams from south-east Drente.

The bronze dagger of Bargeroosterveld. The result of the pollen analytical examination of a recent—not yet published—discovery of a bronze dagger (Earliest Bonze Age) at Bargeroosterveld agrees with that of the find of Roswinkel. In the autumn of 1953 this fine specimen, the horn hilt of which has also been preserved, was found during a reclamation of a field of the brothers HAITEL. During this work a surviving block of peat was partially cut away, and in it the mentioned find was made. It was not until some weeks after the discovery, however, that this site was visited by Dr W. GLASBERGEN and the present author. In the meantime the cutting of the peat had progressed about 30 m. For that reason it was not possible to check the position of the bronze dagger. Inquiries of a workman who had been a witness of the discovery enabled us to indicate approximately the find level in the profile at a distance of 30 m from the find-spot. The part of the profile between 30 and 90 cm below the surface was sampled. In this profile the position of the bronze dagger would correspond with a depth of about 80 cm. On this spot the profile was as follows

0–30	cm	disturbed peat
30–54	,,	fresh *Sphagnum imbricatum* peat
54–81	,,	highly humified *Sphagnum* peat (*Sphagnum rubellum, papillosum, cf. fuscum, cf. molluscum*) with remains of *Ericaceae* and *Monocotyledons*, especially *Eriophorum*
81–84	,,	fresh *Sphagnum papillosum* peat
84–90	,,	fresh *Sphagnum cuspidatum* peat with remains of *Eriophorum* and leaves of *Andromeda*

Taking into account that peat formation was much slower here than at the site where the profile from Roswinkel was sampled, the diagram from Bargeroosterveld (Fig. 9) agrees well with that from Roswinkel. The *Corylus* curve shows the same fluctuations. In the lower part of the diagram the first increase in the *Fagus* curve can just be seen. The expansion of *Fagus* with the accompanying final fall of *Corylus* is also present in this diagram. In contrast with the other diagrams the *Fraxinus* maximum, which always coincides with the end of the second increase in the *Fagus* curve, is absent here.

On account of the circumstances mentioned above it is not possible to indicate exactly the position of the dagger in the diagram. The approximate position at a depth of 80 cm is in harmony with that of the find of Roswinkel which also corresponds with a level not far above the first, small increase in the *Fagus* curve.

Another bronze find from that time is the bronze axe (Montelius I) from the "Meerhusemer Moor" near Aurich (Ostfriesland). The pollen analytical investigation of this find has not yet been published, but, according to Overbeck and Schneider (1938), this axe has to be placed at the beginning of the continuous *Fagus* curve. This is thus in agreement with the results of Roswinkel and Bargeroosterveld.

The bronze axe of Minstedt (Montelius II) was investigated by Schubert (1933) 30 years after its discovery. It was still possible to indicate fairly exactly the position of this axe in the peat profile because the height of the object above the sandy subsoil was known, and since the time of the discovery not much peat had been cut away. Concerning this find it can only be remarked that the find level lies above the beginning of the continuous *Fagus* curve and below the last *Corylus* maximum. This again is in agreement with the results discussed above.

It appears that all finds from the Early Bronze Age have to be placed above the first, very small increase in the *Fagus* curve, which in most diagrams from north-west Germany is represented by the beginning of the continuous *Fagus* curve. This in contrast with the finds from the Late Stone Age which were lying below this increase in the *Fagus* curve. The first increase of *Fagus* pollen, which in the diagram from Emmererfscheidenveen lies between 100 and 105 cm, thus coincides approximately with the transition from the Neolithic to the Bronze Age.

Late Bronze Age

A find from the end of the Bronze Age which lent itself very well to pollen analysis is that of a bronze vessel containing a number of bronze objects discovered in the Brøndsum bog, at 6 km west-south-west of Hobro (Jutland). This find—highly probably a votive hoard—was investigated by Jessen (1934). Unfortunately on account of the high *Betula* percentages the values for the other trees have been strongly depressed, so that an exact comparison of this diagram with other north-west European diagrams is not possible. It is clear, however, that this find level which belongs to the end of the Bronze Age

lies in the upper part of JESSEN's zone VIII, that is immediately below the appearance of *Fagus* and *Carpinus*. The appearance of *Fagus* in the diagrams from Jutland corresponds with the expansion of *Fagus* and the accompanying fall of *Corylus* in the diagrams from north-west Germany and the northern Netherlands.

IRON AGE

Traces of human activity found in two bogs in Schleswig-Holstein have been subjected to pollen analysis by SCHÜTRUMPF. In the first place a culture layer is concerned with a great number of bones of domestic animals and some pottery discovered in a bog near Barsbek (Kreis Plön). This culture layer, which pottery has dated at about the beginning of the era (RADDATZ, 1952), could not contribute to a dating of a pollen analytical horizon as the diagram from that site is difficult to interpret (SCHÜTRUMPF, 1952): The *Pinus* percentages are relatively high, whilst the *Fagus* curve is atypical and in the upper part of the diagram even shows a decline instead of reaching the expected high values. The behaviour of the *Carpinus* curve, also, is not quite normal.

The pollen analytical examination of pottery from the same time found in the Rüder bog (Kreis Schleswig) has led to a more positive result. In sections which were to be seen in peat cuttings, pits filled up with fresh *Sphagnum* peat showed up in the highly humified *Sphagnum* peat (SCHWABEDISSEN, 1951). According to SCHWABEDISSEN these pits would be the effect of prehistoric peat-digging. On some spots pottery had been buried in the highly humified *Sphagnum* peat below the pits. This pottery could be dated at about the beginning of the era. As a result of the pollen analytical examination carried out by SCHÜTRUMPF (1951) the level at a short distance above the end of the first expansion of *Fagus* can be dated at about the beginning of the era. Concerning this dating it has been supposed that in the pits peat formation started immediately after the burying of the offerings, so that the lowermost spectrum of the fresh *Sphagnum* peat in the pits can be dated at about the beginning of the era.

The find of a hoard of Roman silver coins near Bargercompascuum. From the first centuries A.D. a number of finds from bogs has been described. A recent, not yet published one is the discovery of Roman coins in the raised bog near Bargercompascuum. Besides the exact dating evidence this find is therefore so valuable because it was possible to verify its exact position in the peat. In the autumn of 1952 during the digging away of the fresh *Sphagnum* peat a large number of Roman silver coins (*denarii*) and pieces of leather were discovered by Mr T. DUINKERKEN at Bargercompascuum. The coins and pieces of leather were collected by him, but the spot where the coins were found remained intact, since a 17 cm high peat monolith the upper side of which represented the find level was saved. The situation on the spot as seen by Dr W. GLASBERGEN and the present author in January 1953 is shown in Fig. 10. The vertical plane A represents a section

of the fresh, Younger *Sphagnum* peat which is cut away before the beginning of the peat-cutting campaign. The horizontal plane B is the level to where the fresh *Sphagnum* peat is cut away. The vertical plane C is the section of the very humified *Sphagnum* peat, and finally the horizontal plane D represents the sandy subsoil. The distance between the peat monolith and the plane A is 1 m.

During our visit some pieces of leather and a small number of coins could still be collected. The total number of coins collected on this spot is 313. These coins which are still being investigated range from Nero (54–68) to Commodus (180–192). It appeared possible to reconstruct from the pieces of leather a purse with a part of the girdle (Schlabow, not yet published).

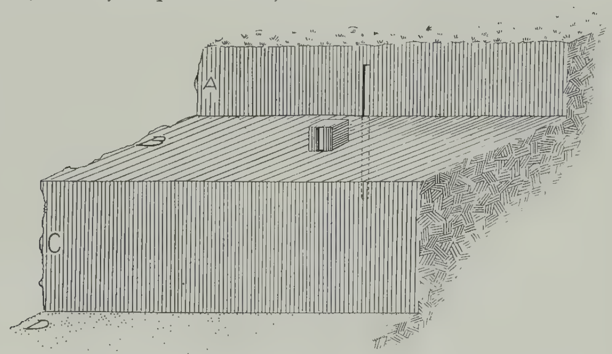

Fig. 10. Situation on the find-spot of the Roman coins near Bargercompascuum.

Through the presence of some coins of Commodus this find can be dated at about 190 A.D. The question may be raised whether the possibility has been taken into account that the bag with money had been buried in the peat, so that the find level would not correspond with the actual bog surface at 190 A.D. Up to now a considerable number of hoards from the first five centuries A.D. was discovered (*cf.* De Boone, 1954). The purse lay on a thick tussock of *Eriophorum*, so that it is likely that it intentionally had been laid down in a solitary tussock of cotton-grass in order to find it again easily. Moreover—as will be discussed later on—the result of the pollen analytical investigation of this find agrees with that of some other finds from about the same time.

In addition to the small peat monolith a 90 cm high section of the profile behind the monolith was sampled. In this way it would be possible to fit the diagram of the peat monolith into the greater diagram which again could be compared with the diagram from Emmererfscheidenveen.

The following profile was sampled

0– 30	cm	disturbed peat
30– 38	,,	rather fresh *Sphagnum imbricatum* peat
38– 49	,,	fresh *Sphagnum cuspidatum* peat
49– 55	,,	highly humified *Sphagnum* peat with *Eriophorum*
55– 75	,,	fresh *Sphagnum imbricatum* peat with *Eriophorum*

75– 90 cm fresh *Sphagnum cuspidatum* peat with some *Eriophorum* and *Monocotyledons*
90– 94 „ moderately humified *Sphagnum imbricatum* peat with some *Calluna* and *Monocotyledons*
94–120 „ highly humified *Sphagnum* peat with *Calluna* and *Eriophorum*

Peat monolith

48– 55 cm *Eriophorum* peat
55– 65 „ moderately humified *Sphagnum imbricatum* and *cuspidatum* peat with remains of *Eriophorum*, *Calluna*, *Andromeda* and *Scirpus*

No marked *Grenzhorizont* is present in this profile. The layer between 90 and 94 cm can be considered as intermediate.

In the lower part of the diagram from Bargercompascuum (Fig. 11) the last *Corylus* maximum (C_4) is present at a depth of 102 cm. The fact that below this *Corylus* maximum the *Fagus* percentages are very low (0.2–0.4 %) does not agree with the other diagrams from south-east Drente. It is not unlikely that we have here a gap in the deposits. It is not impossible that in former times the Runde, which is running at a distance of 150 m from the find-spot, locally has washed away peat layers. Above the last *Corylus* maximum the diagram is quite comparable with the other diagrams from this region. *Corylus* falls to values of about 10 %, *Fagus* reaches relatively high percentages, and *Carpinus* shows a continuous curve. The end of the increase of *Fagus* at a depth of 77 cm again coincides with a *Fraxinus* maximum. The behaviour of *Alnus* and *Quercus* also agrees with that in the diagram from Emmererfscheidenveen, whilst the first, although slight increase of *Carpinus* begins at a depth of 57 cm. This diagram is thus well comparable with the other diagrams from south-east Drente.

Above this diagram are represented the result of the investigation of the peat monolith and the spectrum of the peat adhering to a piece of leather. On account of the low pollen content in the upper part of the monolith the total number of tree pollen counted in the upper two samples does not reach 1000, but 500 and 375 respectively. As the distance from the monolith to the profile was only 1 m no difficulties were expected in fitting the diagram of the peat monolith into the greater diagram. This is indeed well possible, but not until some intermediate samples between a depth of 47 and 57 cm were analysed. In the diagram from the monolith there is a—for the rest unimportant—*Pinus* maximum. In the diagram from Bargercompascuum this maximum can be seen at a depth of 50 cm. In both diagrams a temporary increase of *Quercus* is clearly shown. A characteristic feature is the first increase in the *Carpinus* curve between the upper spectrum of the peat monolith and the spectrum of the leather purse. The corresponding increase of *Carpinus* is also seen in the lower diagram. As the find level of the purse lies between the upper sample from the monolith and the sample from the purse the dating of about 190 A.D. has to be placed half-way the first increase of *Carpinus*. For this reason this date has to be placed at a depth of about 47 cm in the Bargercompascuum diagram, whilst in the diagrams from Emmererfscheidenveen and Fochteloo this date corresponds with a depth of 25 and 95 cm respectively.

Archaeological objects from about the same time as the find of the coins, which have been subjected to pollen analysis, are the bronze fibulae from the "Oldenbrooker Moor" in Oldenburg (OVERBECK and SCHMITZ, 1931) and the peat burial ("*Moorleiche*") from the "Wolfsbrucher Moor" in Kehdingen (SCHUBERT, 1933). The peat burial from Obenaltendorf—on which WEBER based his dating of the *Grenzhorizont*—will be discussed below on pp. 49–50. WATERBOLK (1950) has already remarked that SCHUBERT fitted the spectrum of the peat burial too high into the diagram from Obenaltendorf, which —as far as the Subatlantic part is concerned—agrees very well with the Fochteloo diagram. According to SCHUBERT the spectrum of the peat burial would correspond with a depth of 210 cm, whereas the Ericaceous percentage and the values for the tree pollen suggest that the spectrum of the peat burial corresponds with a depth of 270 cm in the Obenaltendorf diagram. The age of the peat burial has been given by SCHUBERT at about 300 A.D. This date can be placed at the level where the first increase of *Carpinus* comes to an end. This is in agreement with the result of the find of the Roman coins, *i.e.* that the date of 190 A.D. has to be placed at the first increase of *Carpinus*.

The examination of a find consisting of 28 bronze fibulae ornamented with silver and discovered at 50 cm above the *Grenzhorizont* in the "Oldenbrooker Moor", could confirm the results discussed above. The pollen analytical examination of a profile sampled by SCHÜTTE some weeks after the discovery was carried out by OVERBECK (OVERBECK and SCHMITZ, 1931). The upper part of the diagram [1] agrees well with that from Fochteloo, considering that in eastern Oldenburg the values for *Fagus* and *Carpinus* are higher than in the northern Netherlands. Unfortunately peat no longer adhered to the fibulae, which would have allowed a check analysis. According to OVERBECK there is no question about the accurate position of the fibulae—which have been dated at 200–300 A.D.—in the diagram. It appears that the find level, which corresponds with a date of 200–300 A.D., lies at the end of the first increase in the *Carpinus* curve.

Consequently the results of these three finds from the 3rd and 4th century A.D. show considerable agreement, and on that account it is certainly warranted to date the first increase of *Carpinus* at about 200 A.D.

The position of a "*Bügelplattenstück*" from the 5th–6th century A.D. discovered in the "Holler Moor" (OVERBECK and SCHMITZ, 1931) is in harmony with this dating of the first increase of *Carpinus*. On account of the fact that this object, according to the report of the finder, was lying on the transition from highly humified to fresh *Sphagnum* peat OVERBECK supposed that this report must be incorrect, or that the fibula immediately after it had been lost, would have come to rest in a deeper layer. It appears, however, that the position of the

[1] This diagram, as that of SCHUBERT, has also been published in FIRBAS (1949).

fibula—following up the finder's report—corresponds with a level at some distance above the first increase of *Carpinus*, which is thus somewhat above the position of the finds discussed above.

From about the same time are the culture remains in the "Bolleveen" (Van Giffen, 1950) and the fortified settlement near the "Witteveen" (Van Giffen, 1949, 1950), both near Zeijen in the province of Drente. Waterbolk (1950) carried out a pollen analytical investigation of both sites.

In the mentioned "Bolleveen" irregular pits (depth about 0.80 m, diameter 2–4 m) in which fresh *Sphagnum* peat had been deposited, showed up in the highly humified *Sphagnum* peat. Besides many pieces of timber also bones—especially of cows (Van Giffen, 1952)—and sherds were discovered at the bottom of these pits which undoubtedly are the effect of human activity (prehistoric peat-digging?). Through the presence of Saxon pottery the beginning of the formation of fresh *Sphagnum* peat in these pits could be dated at about 400 A.D. The lower part of a diagram from a Younger *Sphagnum* peat profile in such a pit can be well compared with the diagram from Fochteloo. The lowest spectrum of this "Bolleveen" diagram shows a relatively high *Fagus* percentage, whilst *Carpinus* has a value of 1–2 %. The beginning of this profile thus falls after the first increase in the *Carpinus* curve. A comparison of this diagram with that from Fochteloo learns that the lowest spectrum, which can be dated at about 400 A.D., corresponds with a depth of about 87 cm in the Fochteloo diagram. This again is in agreement with the position of the other finds discussed above.

In a part of a ditch of the fortified settlement near the "Witteveen", which also can be dated at about 400 A.D., fresh *Sphagnum* peat had been formed. It is likely that after the building of the fortification the small raised bog on the north side expanded somewhat. On account of local circumstances the *Fagus* and *Carpinus* percentages are much lower than in the "Bolleveen" diagram. For that reason it is not possible to transfer the beginning of the peat formation in the ditch to the diagram from Fochteloo.

Finally the diagram from the Wakenitz bog near Lübeck can be mentioned (Schmitz, 1951). In the profiles from this bog a marked change in the stratigraphy can be observed. In consequence of the damming up of the water of the Wakenitz river a strong rise of the water level took place. On that account the formation of sedge peat suddenly passed into calcareous deposits. As according to the charter in question the building of the dam took place at 1298 A.D., the sudden change in the stratigraphy can be dated at 1300 A.D. It appears that this date has to be placed at the level where *Fagus* as well as *Carpinus* reach a maximum. Although on account of the great distance and the particular circumstances an accurate comparison of this diagram with that from Fochteloo is not possible, the spectrum in question will approximately correspond with a depth of 20–25 cm in the last diagram.

Summarizing it can be stated that the result of the pollen analytical investigation of a number of archaeological finds from bogs has led to the following archaeological dating of the pollen diagram from the northern Netherlands. In view of the beginning of the curve for *Plantago lanceolata* at a depth of 160 cm in the Emmererfscheidenveen diagram the beginning of the Neolithic time can be placed here at that depth. Just as in the diagrams from Denmark and north-west Germany the beginning of the *Plantago* curve is accompanied by a decrease of *Tilia* and *Ulmus*. The Neolithic settlements discovered in the peat appeared to be situated above the decrease of *Tilia* and *Ulmus*.

In the Emmererfscheidenveen diagram the transition from Neolithic time to Bronze Age approximately falls at a depth of 100 cm where the *Fagus* curve shows its first, although slight increase. Various finds from the Early Bronze Age were lying above this increase in the *Fagus* curve, whereas all finds from the Late Stone Age have to be placed below this characteristic feature.

Unfortunately practically no archaeological objects from the Late Bronze Age were examined so far. The Danish find from the end of the Bronze Age falls immediately below the expansion of *Fagus*. In the Emmererfscheidenveen diagram the Bronze Age/Iron Age transition lies approximately at a depth of 85 cm.

A reliable dating of a pollen analytical level from the first centuries A.D. gives the find of the Roman coins near Bargercompascuum. The first increase in the *Carpinus* curve (at a depth of 25 cm in the Emmererfscheidenveen diagram and at a depth of 95 cm in the Fochteloo diagram) could be dated at about 200 A.D. This dating is in agreement with the position of some other finds from north-west Germany.

Finally the well dated horizon in the Wakenitz bog has to be mentioned (1300 A.D.). In the diagram from Fochteloo the corresponding level lies approximately at a depth of 20–25 cm.

V. THE POLLEN ANALYTICAL INVESTIGATION OF BURIAL MONUMENTS

In discussing the results of the pollen analytical investigation of burial monuments some terms will be used that need an explanation.

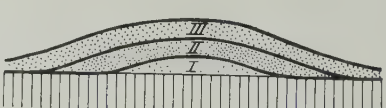

Fig. 12. Schematic section of a three-period barrow or tumulus.

Fig. 12 represents a schematic section of a three-period barrow. The surface on which a tumulus has been built is called old surface. A pollen analytical examination of that old surface can give an impression of the vegetation at the time of the construction of the

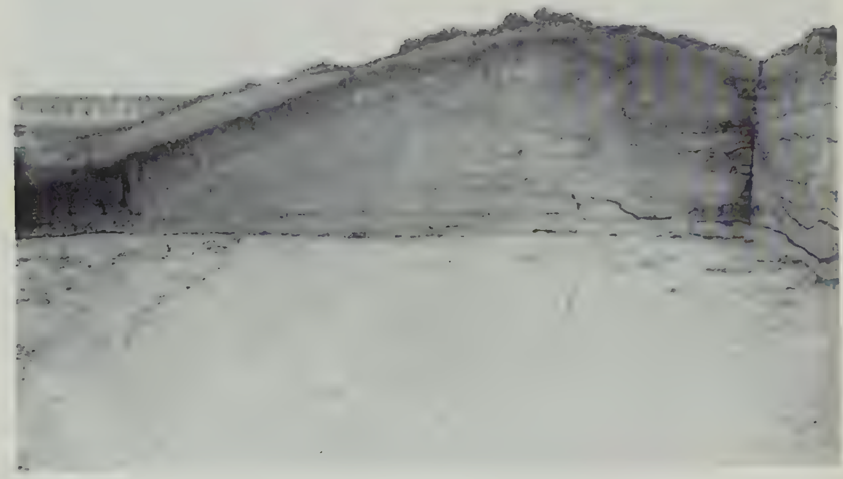

Fig. 13. Neolithic barrow near Gasteren. The barrow consisting of yellow sand has been raised on a hardly perceptible old surface. The horizontal infiltration veins are characteristic of Neolithic tumuli (VAN GIFFEN, 1941*a*).

Fig. 14. Bronze Age barrow near Havelte (tumulus 2). The barrow has been built of inverted heather sods. The subsoil shows a podzol profile (VAN GIFFEN, 1951).

barrow. The burial mounds from the Late Stone Age consist of structureless, clean yellow to dirty grey sand (Fig. 13), whereas most tumuli from the Bronze and Iron Age have been built of—mostly inverted—heather sods (Fig. 14). The pollen content of a sod—just as that of the old surface—reflects the vegetation at the time of the construction of the barrow.

The subsoil of the barrows from the Bronze and Iron Age shows —apart from exceptional cases—a more or less well developed podzol profile. Below Neolithic barrows mostly no clear soil profile is present. For that reason it is often difficult to locate the exact position of the old surface. Sometimes the old surface of a Neolithic barrow can be recognized as a faintly humous layer.

In many cases more periods of construction can be recognized in one tumulus, *e.g.* a Neolithic primary mound (I) is sealed beneath a Bronze Age capping of sods (II). The number of periods in one tumulus is not confined to two. Tumuli of three periods are not rare, while tumuli of a yet greater number of periods equally occur. As mostly a considerable time elapsed between the building of two successive periods, a vegetation could develop on the surface of the underlying mound, so that often the successive periods are separated by a humous layer.

Sometimes two or more constructional phases can be distinguished within one period. It is quite probable that only a short time elapsed between the building of two successive phases.

Besides a primary grave which, as a rule, lies approximately at the centre of the barrow, mostly one or more secondary interments are found in the peripheral parts of the mound.

Many tumuli were surrounded by peripheral constructions as single or multiple rings of timber uprights (post-circles), an enclosing circular ditch or, exceptionally, an enclosing bank and ditch. These archaeologically important constructions will not be described here. For a detailed description of the barrows we may refer to the quoted excavation reports.

In contrast with the samples from bogs *Betula* is not included in the ΣAP of the samples from burial monuments. It appears that the *Betula* percentages of the various samples from one barrow cemetery show considerable fluctuations. These are not effected by climatic changes, but are due to the fact that in sandy districts the birch is the first to return after the abandoning of the fields. In this way locally the birch could play an important part. As on account of the high *Betula* percentages those of the other trees would be depressed too much, *Betula* is excluded from the ΣAP. Moreover, the results can more easily be compared now with those of Waterbolk (1954*b*).

The barrow cemetery near Hijken, municipality of Beilen (*Table II*)

In 1953 the greater part of a barrow cemetery near Hijken (municipality of Beilen) was excavated.

Tumulus 1, a two-period barrow, consisting of:

A primary barrow of greyish sand, raised on a partly faintly humous old surface. A ^{14}C-measurement of charcoal from the primary grave—which did not contain grave goods—by Professor HL. DE VRIES, Physical Laboratory of the University of Groningen, gave a dating of 1350 ± 150 B.C.

A covering mound of light-coloured sand in which a few clear sods could be distinguished.

Both periods belong to the Neolithic period.

Tumulus 8, a two-period barrow, consisting of:

A primary barrow of dirty yellow sand, on a humous old surface. The primary grave of this period contained, among other things, a debased herringbone beaker (Late Neolithic).

A sod-built covering mound.

The following barrows had all been built of—mostly inverted—sods, and can—with the exception of tumulus 2—be assigned to the Bronze Age. Of all Bronze Age tumuli of this cemetery in which a primary grave was discovered, the corpse had been buried in a trunk coffin.

Tumulus 10 consisted of a core of dark, peaty sods, smoothed over by a capping of yellowish soil with light-coloured sods and a talus of greyish sand. This mound was covered by a mantle of light-coloured sods. The podzolized subsoil showed a rather weakly developed hard pan.

Tumulus 9, a two-period barrow, consisting of:

A primary mound showing a core of tightly packed, dark, peaty sods, and a capping of less dark-coloured sods which had not been so tightly packed. Where the base of the mound had been stripped off only the leached layer and the hard pan were present. In the primary grave, among others, two gold spirals and a bronze pin were discovered.

A covering mound of reddish-brown sand with some sods.

Tumuli 3 and 4 were long barrows, a not very common type in the Netherlands. Tumulus 3 showed three phases. The first phase was a round barrow consisting of a core of greyish sods covered by a capping of tightly packed humous sods. This core was smoothed over by yellow sand. The last phase showed an elongated ground plan. The original round barrow had been extended to the south for about 10 m.

Tumulus 4 had been built of—sometimes rather faint—grey to dark sods. The old surface had been stripped off, and the subsoil showed a not very well developed podzol profile.

Tumuli 5 and 6 had been built of a core of arable soil with a covering of grey to dark long sods. Both tumuli were overlying old arable with very distinct plough markings. In tumulus 6 a second period—a capping of reddish-brown sand—was present.

Tumulus 7 consisted of a core of short, brown-yellow and greyish sods, and a capping of rather long, grey to dark sods. The subsoil did not show a heather podzol profile, but a grey layer about 15 cm thick, suggesting old arable.

Tumulus 2 was an isolated barrow, lying at a distance of about 1000 m from the Hijken barrow cemetery. Three constructional phases could be distinguished, viz. a core of short, dark sods, a capping of less dark-coloured sods, and a third phase of reddish-brown sand with a few sods. The old surface had been stripped off for the greater part before the erection of the barrow. According to a few pieces of iron and a spread of cremated bone this tumulus undoubtedly belongs to the Iron Age.

Concerning the relative chronology of the barrows of the Hijken cemetery the following may be remarked. Tumulus 1 and the primary

mound of tumulus 8 are the earliest (Late Stone Age), whilst tumulus 2 is the latest one (Iron Age). As the tree pollen spectra show no characteristic differences they do not give support to the determining of the relative chronology of the Bronze Age barrows. It is remarkable that there can be considerable differences between the various spectra of a single barrow, *e.g.* the difference in *Corylus* and *Quercus* percentage between the spectra of the old surface and dark-coloured sod of tumulus 7, the relatively high *Tilia* percentages in the old arable samples from the tumuli 5 and 6. It appears that not unfrequently the differences between the spectra from a single barrow are greater than those between the barrows mutually. It is for that reason that only the *Calluna* percentages, which in a given area increase with time (WATERBOLK, 1949, 1954*a*), could give an indication of the relative chronology of the barrows. Unfortunately also the *Calluna* percentages in the various spectra of one tumulus appear to fluctuate rather greatly. The low *Calluna* percentages of the tumuli 9 and 10 suggest that these two barrows are the earliest of the Bronze Age tumuli of this cemetery. For this reason they have been placed after the Neolithic tumuli. In consideration of the, on an average, rather high *Calluna* values the tumuli 5, 6 and 7 are the latest of the Bronze Age barrows, while the long barrows 3 and 4 have to be placed between the tumuli 9 and 10 on the one side and the tumuli 5, 6 and 7 on the other.

With regard to the separate spectra the following may be remarked. The pollen of the old surface sample from tumulus 1 was badly preserved, which perhaps is the cause of the fact that *e.g.* no *Fraxinus* pollen was met with. The *Tilia* value is rather high (4.5 %), whilst that of *Calluna* is extremely low (6.4 %). The high values for *Gramineae*, *Plantago*, *Compositae* and *Caryophyllaceae* point to a semi-wild pasture land originating after the clearing of the forest in consequence of grazing. The high *Succisa* percentage likewise indicates a type of meadow. The sample from the sod of the second period of this tumulus shows a somewhat higher *Calluna* value (21.1 %), while the values for the various herbs have markedly decreased, just as the *Tilia* percentage. There is a considerable difference in *Quercus* percentage between both periods of this tumulus (4.5 and 42.1 % respectively).

Judging from the *Calluna* percentage the primary mound of tumulus 8 must be later than the second period of tumulus 1. The *Corylus* value is fairly high, whilst that for *Quercus* is extremely low. The values for the various herbs do not differ considerably from those in the Bronze Age barrows. *Fagus* is completely absent in the Neolithic spectra in this table.

The spectra of both samples from the covering mound of tumulus 8 are in fairly good agreement, and differ mainly by the much higher *Quercus* percentage from the spectrum of the primary barrow. The *Calluna* percentage in both sods is only a little higher than that in the old surface of the Neolithic period. The herbaceous percentages of both periods do not show much difference either.

The spectra of the old surface of the tumuli 9 and 10 show much

resemblance. Only the *Betula* percentage in the old surface of tumulus 10 is much higher than that of tumulus 9. At the time of the construction of the tumuli 9 and 10 *Betula* must have played an important part on that spot. As the *Quercus* percentage in the sods of both barrows is markedly higher than that in the old surface, it seems likely that the sods will not have been cut in the immediate vicinity of the tumuli.

Tumulus 3 showed three constructional phases. As on the surface of the first two phases no traces of a vegetation cover could be observed, it is likely that little time elapsed between the construction of the successive phases. The result of the pollen analytical examination can confirm this supposition. The spectra of sods of the first and third constructional phase do not give any indication of a considerable difference in time. The subsoil of the round barrow did not show a podzol profile, but a yellow-grey layer passing downwards into the yellow-coloured virgin soil suggests old arable which had been abandoned some time before the construction of the barrow. The pollen analytical result also points to that. Compared with the sod samples the old surface shows a fairly low *Calluna* percentage, whilst the values for *Gramineae* and *Plantago* are more than twice as high as those in the sod samples. This suggests that the vegetation of the old surface of the round barrow was no typical heath, but that *Gramineae* and *Plantago* still played an important part.

The spectra of both sod samples from tumulus 4 show nothing in particular.

The spectra of the old arable below the tumuli 5 and 6 are interesting. Very likely this old arable had been cultivated till the construction of the barrows. The clear plough markings as well as the pollen spectra point to that. In contrast with the sod samples from the same barrows the pollen in the old arable samples was badly preserved. This is easy understandable as—in contrast with the compact grass and heather sod—arable soil has a loose structure, so that before the construction of the barrow the air could easily enter, badly damaging the pollen grains. The spectra of both old arable samples are in fairly good agreement. On account of the low pollen content and the bad state of preservation a small quantity of tree pollen was counted in these samples. Compared with the average value of 0.6 % in the other samples the *Tilia* percentages in both old arable samples are high (3.4 and 3.0 %). Pollen of *Plantago* occurs in overwhelming quantities (363 and 267 %). The pollen of *Caryophyllaceae* shows a relatively high percentage, whilst *Rumex* is fairly abundant. Mention must be made of the occurrence of *Spergula* (4.9 %) in the old arable below tumulus 5. The spectra of the various sod samples again show mutual differences, suggesting that the sods will have been cut on different spots.

The old surface sample from tumulus 7 contained rather much pollen of plantain (40 %), while moreover the *Calluna* value is high (287 %). Through the absence of a podzol profile the subsoil of tumulus 7 could clearly be recognized as an original old arable which

—in view of the fairly distinct humous surface—must have been abandoned some time before the construction of the barrow. The high *Calluna* percentage also indicates that the heather must have covered this old arable. The pollen grains were well preserved, this contrary to the old arable samples from the tumuli 5 and 6. As in general the *Calluna* percentages in the various samples from tumulus 7 are the highest of all Bronze Age samples in Table II, this tumulus is probably the youngest of the Hijken barrow cemetery.

Compared with the Bronze Age samples the spectra of the isolated Iron Age barrow (tumulus 2) show some characteristic differences. The average *Fagus* value in the Bronze Age spectra is 0.6 %, and that in the spectra of tumulus 2 is 3.1 %. *Carpinus* is present in all samples from tumulus 2, while *Tilia* shows a decrease, namely from an average of 0.6 % (some extremely high percentages were not worked up in calculating this average) to an average of 0.3 %. *Corylus* has also decreased (from 18.0 to 13.3 %), while *Calluna* shows an important rise. For the same reason as for tumulus 3 it is not likely that much time elapsed between the construction of the successive phases of tumulus 2. This supposition is confirmed by the results of the pollen analytical investigation.

The "Noordse Veld" near Zeijen, municipality of Vries (Table III)

In some barrows—already excavated many years ago—of the cultural reserve the "Noordse Veld"—archaeologically well-known by the excavations of VAN GIFFEN (1919, 1920, 1930, 1949)—a trench was dug in order to take samples for pollen analysis.

The tumuli 113 and 114 which were sampled for pollen analysis belong to a group of four barrows from the Early Bronze Age (VAN GIFFEN, 1920). The barrows had been built of long, inverted, dark-coloured sods, while the subsoil shows a well developed podzol profile. These barrows which show a great similarity are dated by a bronze riveted dagger (MONTELIUS II) from tumulus 114.

The samples from the tumuli 113 and 114 appeared to contain abundant pollen in a good state of preservation. Concerning the spectra of the old surface and a sod of both barrows it may be noted that *Fagus* already occurs in a low percentage (0.3–0.7 %). Compared with that in the Iron Age samples the *Calluna* value is low (97–134 %). There is a striking difference in *Tilia* percentage between both burial mounds. The pollen of cultivation shows nothing in particular. The high values for *Pteridium* (15.8–46.2 %) point to an expansion of *Pteridium* on the forest clearings.

The equally sampled tumuli 8, 14 and 31 belong to the great group of barrows, raised on a burnt-out pyre, which date from some centuries B.C. till after the time of the Roman occupation. Tumulus 31 had been built on the junction of four banks in a system of *Celtic Fields*. Tumulus 8, also, had been raised on old arable. As the old arable appeared to be poor in pollen, no sample was counted from that. The subsoil of tumulus 14 consisted partly of old arable, partly of an undisturbed podzol profile.

Compared with the Early Bronze Age tumuli the regular occurrence of *Carpinus* and the fairly high *Fagus* values (3.8–4.4 %) are striking.

TABLE III
Noordse Veld

	tumulus 114 old surface	tumulus 114 sod	tumulus 113 old surface	tumulus 113 sod	tumulus 14 old surface	tumulus 14 sod	tumulus 8 sod	tumulus 31 sod
Alnus	47.4	51.9	52.1	59.2	58.9	62.0	63.3	61.5
Corylus	27.4	23.2	20.9	19.3	28.0	22.6	16.8	17.8
Quercus	19.6	18.3	19.4	19.0	9.4	10.8	8.4	11.4
Tilia	1.9	2.1	0.5	0.6	0.4	0.5	0.3	0.2
Ulmus	0.6	0.3	1.2	0.9	0.6	0.2	0.4	0.2
Fraxinus	1.0	0.4	0.8	0.1	0.2	0.2	0.6	0.6
Fagus	0.3	0.3	0.7	0.5	3.8	3.1	4.4	3.5
Carpinus	—	—	-	—	0.4	0.2	0.8	0.7
Pinus	1.8	3.3	4.3	1.6	0.4	0.2	2.6	4.0
Picea	—	0.1	—	—	—	—	0.1	0.2
Salix	—	0.1	—	—	—	—	0.1	0.2
Ilex	—	—	—	—	—	—	0.1	—
ΣAP—Betula	685	754	746	789	477	424	724	853
Betula	46.0	30.0	34.0	26.7	12.8	12.0	16.6	17.2
Myrica	—	—	—	—	0.6	1.9	114	0.7
Calluna	97.3	113	134	127	323	300	500	223
Gramineae	25.5	21.2	28.3	17.1	175	93.4	280	47.5
Cerealia	1.5	0.5	0.7	0.5	4.2	10.1	7.9	2.6
Rumex	7.6	3.8	6.6	10.6	15.3	8.2	55.2	4.1
Plantago lanceolata	3.2	2.0	3.3	1.8	7.8	6.1	5.8	3.4
Tubulifl. Compositae	0.9	0.5	0.7	1.0	2.7	0.9	1.9	0.6
Ligulifl. Compositae	1.6	0.8	2.7	2.3	9.9	6.4	11.5	0.9
Chenopodiaceae	0.6	0.4	0.7	0.3	2.5	1.9	2.3	0.5
Artemisia	0.9	0.8	1.5	0.8	2.1	0.2	1.0	1.4
Spergula	—	—	—	-	2.7	4.0	1.1	0.2
Campanulaceae	—	0.5	0.8	0.1	1.3	1.4	1.5	—
Ranunculaceae	—	0.4	0.1	0.4	—	—	0.4	0.4
Rosaceae	—	—	—	0.1	0.2	—	—	—
Potentilla-type	0.7	—	0.8	0.6	0.4	0.9	—	1.9
Mentha-type	0.1	—	0.1	0.1	—	—	0.1	—
Succisa	0.4	0.4	0.4	0.4	5.0	6.4	2.2	0.7
Cyperaceae	0.1	—	0.3	—	—	—	0.3	0.4
Caryophyllaceae	0.4	0.4	0.4	—	2.9	1.4	1.2	0.5
Umbelliferae	0.1	—	—	—	0.2	—	—	0.4
Polygonum Persicaria	-	-	-	-	0.2	0.2	0.1	—
Sparganium	-	—	0.1	-	—	—	—	—
Papilionaceae	—	0.1	—	—	—	—	-	—
Valeriana	—	—	—	0.1	—	—	—	—
Lycopodium cf. clavatum	—	0.1	—	—	—	—	—	—
Lycopodium cf. inundatum	—	—	—	—	—	0.2	0.4	—
Dryopteris	1.9	1.9	3.5	1.8	13.6	9.7	4.6	3.2
Pteridium	26.9	25.5	46.2	15.8	3.6	5.9	3.4	3.3
Polypodium	—	—	—	-	1.0	0.5	—	—
Sphagnum	1.0	0.7	1.1	1.1	9.4	11.6	8.4	3.8

The high *Myrica* percentage in a sod sample from tumulus 8 is remarkable (114 %). In most cases it was easy to separate the pollen of *Corylus* and *Myrica*. The *Calluna* values in these barrows are very high (223–500 %). In general the pollen of cultivation also shows high values (*Rumex* 55.2 % in tumulus 8), whilst pollen of *Spergula* occurs regularly in these samples (up to 4 %). *Succisa* shows a conspicuous high value in the sample from tumulus 14.

With regard to a more accurate dating of the tumuli 8, 14 and 31 it is of importance to note that the spectra of these tumuli agree well with those of the Iron Age tumuli near Oudemolen (WATERBOLK, 1954*b*). As on the ground of a datable find the last tumuli could be dated at about 200 B.C. it is very likely that the tumuli 8, 14 and 31 were raised at about the same time.

Anglo-Saxon cemetery near Zweeloo (Table IV)

During the digging of sand on a high-lying open field (dutch: *es*) east of the village of Zweeloo an Anglo-Saxon cemetery was discovered.

Although the cemetery had already been partly destroyed, the greater part of it could be excavated. The coffins containing the dead bodies had been placed in oblong graves. As a rule the graves had been filled up with clearly outlined sods. Two types of graves could be distinguished, namely graves directed east-west and north-south. Presumably the graves directed east-west date from after the christianization, the ones directed north-south from before that time. Moreover, a number of horse graves recognizable by the shape of the grave, the remains of horse bones and the presence of pieces of harnass could be recognized.

In general only sparse grave goods had been given. In two graves, however, rich furniture was discovered. One grave contained a fine, intact, pointed beaker of olive-brown glass, whilst in another grave a great, equal-armed, bronze fibula, ornamented with animal motifs, a great number of amber, glass, faience, bronze and other beads, a bronze bracelet, two bronze keys and a specimen of Anglo-Saxon pottery were found. On the ground of the finds this cemetery has to be placed in the 5th to 7th century A.D.

From various graves sod samples for pollen analysis were taken. The results of the analysis of five samples, viz. two from east-west graves, two from north-south graves and one from a horse grave, are represented in Table IV. The pollen grains of the analysed samples showed a fairly good state of preservation.

With regard to the tree pollen spectra the absence of *Tilia* and the relatively high *Fagus* and *Carpinus* percentages are conspicuous. Especially in both samples from east-west graves *Carpinus* is relatively abundant. In accordance with the expectation *Corylus* does not reach high values. *Ilex* is present in both samples from north-south graves and in that from the horse grave. In this connection it may be remarked that in another sample from a north-south grave, in which only about 200 AP were counted, *Ilex* shows a value of 10 %.

In view of the relatively low age of these samples the *Calluna* percentages are not conspicuously high. The pollen of *Cerealia*—nearly all of *Secale cereale*—shows high percentages, whilst the values for *Plantago lanceolata*, *Rumex* and *Compositae* are also fairly high in most samples. *Spergula* occurs regularly in a low percentage. Two types of

TABLE IV
Anglo-Saxon cemetery near Zweeloo

	north-south grave I	north-south grave III	horse grave	east-west grave IV	east-west grave V
Alnus	54.0	72.2	71.9	56.2	55.5
Corylus	14.3	14.7	10.6	13.4	10.4
Quercus	22.7	6.9	12.1	22.2	22.4
Tilia	—	—	—	—	—
Ulmus	0.4	0.1	0.5	0.8	0.7
Fraxinus	0.8	0.6	0.3	0.2	0.5
Fagus	3.8	3.9	2.3	3.8	5.9
Carpinus	0.5	0.4	0.5	2.1	1.1
Pinus	2.6	0.7	1.3	1.1	2.1
Picea	—	—	0.1	0.2	0.1
Salix	0.4	—	0.1	0.1	1.0
Acer	0.1	0.1	—	—	0.2
Hedera	0.1	—	—	—	—
Ilex	0.2	0.3	0.2	—	—
Abies	—	—	—	—	0.1
ΣAP—Betula	917	668	858	924	885
Betula	9.7	10.5	10.5	8.2	13.0
Myrica	—	0.1	0.1	—	—
Calluna	153	192	147	129	125
Gramineae	74.3	30.7	35.0	11.1	20.4
Cerealia	17.7	8.9	11.5	6.3	7.8
Plantago lanceolata	11.7	13.9	5.1	1.5	7.5
Rumex	9.4	2.4	2.0	1.8	3.9
Tubulifl. Compositae	1.9	1.5	1.2	1.0	1.2
Ligulifl. Compositae	9.0	3.4	11.5	2.1	6.7
Artemisia	1.9	—	—	0.1	—
Chenopodiaceae	0.2	0.4	0.2	0.1	0.1
Polygonum Persicaria	—	0.3	—	—	0.1
Spergula	0.8	0.4	0.5	0.5	0.7
Caryophyllaceae	2.1	0.6	0.2	—	0.8
Cruciferae	0.5	—	0.2	—	—
Cyperaceae	0.9	0.4	—	2.9	0.2
Umbelliferae	0.1	0.3	—	—	—
Mentha-type	2.1	0.4	0.2	—	0.7
Potentilla-type	0.8	—	0.1	—	0.5
Ranunculaceae	1.6	0.7	0.8	0.8	1.1
Batrachium-type	0.3	0.4	0.5	0.2	0.2
Campanulaceae	0.8	0.3	0.4	0.1	0.6
Succisa	0.1	0.1	—	0.1	0.2
Scrophulariaceae	0.2	—	—	—	—
Sparganium	0.2	—	—	—	—
Frangula	—	—	—	0.1	—
cf. Lysimachia	—	—	0.2	—	—
Pteridium	1.7	0.6	1.7	0.2	0.7
Dryopteris	0.5	1.6	3.3	0.4	1.0
Polypodium	0.2	0.1	1.5	—	0.6
Lycopodium cf. clavatum	0.1	—	0.1	—	—
Sphagnum	2.9	4.0	5.9	3.5	2.4

Ranunculaceous pollen could generally be distinguished, viz. a *Batrachium*-type and a much smaller, likewise tricolpate, scabrate type with a rather irregular sculpture.

The barrow cemetery on the "Emelange" near Wijster (Table V)

This group was composed of five tumuli which were excavated in 1952 (VAN GIFFEN, 1954*a*). All barrows had been built of inverted, short, dark-coloured sods. The old surface consisted partly of a distinct heather podzol, partly of old arable. A remarkable phenomenon is the double podzol profile which could be observed below all tumuli. The lower podzol was covered by a drift sand deposit in which a number of narrow humous layers, suggesting short periods of standstill in which a vegetation could develop, could be seen. On the ground of some archaeological objects these tumuli have to be placed in the pre-Roman Iron Age. A ^{14}C-measurement of charcoal from tumulus 1 and 4 by Professor HL. DE VRIES at Groningen gave a dating of 35 $\pm$ 150 B.C. and 75 $\pm$ 175 B.C. respectively.

The results of the pollen analytical investigation of these barrows —which have already been published (VAN ZEIST, 1954)—are represented in Table V. This table distinguishes in chronological sequence:

a. The sample from a Neolithic tumulus near Drijber which for comparison was added to this table.

b. Both samples from the humous horizon of the lower podzol.

c. The samples from the barrows.

a. The sample from the Neolithic tumulus near Drijber agrees with the other analyses of Late Stone Age barrows. *Corylus* shows a fairly high percentage, while *Fagus* is absent. The *Tilia* value is not particularly high. Concerning the herbaceous pollen the following can be said. The *Calluna* percentage is relatively low. Although the values for *Plantago* and *Dryopteris* are not particularly high this spectrum does show a typical "*landnam*" character.

b. Both samples from the lower podzol do not vary much from the spectrum of the Neolithic tumulus. *Tilia* is slightly lower, whilst *Fagus* has reached a low value (0.3 %). The *Calluna* percentage is fairly low (about 70 %), whilst *Plantago* and *Dryopteris* show lower values than in the sample from the Neolithic barrow.

The time of the development of the lower podzol was succeeded by a period of sand drifts which came to an end some time before the construction of the barrows. For the subsoil of the barrows showed a clear podzol profile. Judging from the faintly humous zones in the drift sand deposit there must have been periods of rest during the sand drifts. The analysis of a sample from such a narrow humous layer gives a relatively low *Calluna* percentage (44.5 %) and a fairly high value for *Gramineae* (45.6 %) and *Cyperaceae* (10.6 %). This suggests that during the periods in which the drifting locally ceased no typical heath could develop, but that *Gramineae* and *Cyperaceae* must have played an important part. It is in this respect that *Carex arenaria*, *Festuca ovina* and *Corynephorus canescens* can be thought of, all species that are frequently met with in recent sand drifts. The occur-

rence of *Artemisia*, *Plantago* and others point to human activity in these surroundings during the period of sand drifts.

c. A comparison of the spectra of the lower podzol with those of the samples from the barrows shows some characteristic differences. Primarily the *Corylus* percentage in the barrow samples appears to have fallen to about one third. In the second place the *Fagus* percentages show a marked increase. In the barrow samples *Fagus* fluctuates between 0.8 and 2.7 % (on an average 1.6 %). A sharp decline in the *Corylus* percentage accompanied by an increase of *Fagus* can also be seen in the diagram from a small raised bog near Wijster (Florschütz and Wassink, 1941). As has already been discussed this course of the curves for *Fagus* and *Corylus* can be observed in all diagrams from the northern Netherlands and north-west Germany.

The barrow samples are further characterized by an increase of *Calluna* and herbaceous pollen (*Compositae*, *Rumex*, *Plantago*). This increase of herbaceous pollen effected by a heightened human activity in this area corresponds with the archaeological evidence of human habitation, viz. barrows and old arable.

The spectra of various samples from one barrow again can show considerable mutual differences. Compare *e.g.* the difference in *Quercus* percentage between sod and old arable of tumulus 4 and between sod and old surface of tumulus 6. On discussing the Hijken barrow cemetery attention has already been drawn to this phenomenon. That pollen analysis of samples from the same time and from the same spot gives a practically equal result can be seen in both spectra of the old surface of tumulus 1 and of tumulus 6. In both cases the spectra show considerable agreement.

Below all barrows old arable was present. In many cases the old arable consisted of so-called ridge-shaped fields ("*Hochäcker*") surrounded by oblong, rectangular ditches. Three samples from old arable were analysed. It is remarkable that the analyses of the old arable below the tumuli 1 and 6 do not show spectra characteristic of old arable. In both cases the *Calluna* value is high, whilst that for the pollen of cultivation is not higher than in the sod samples. Only the sample below tumulus 4 yields a fairly typical old arable spectrum with comparatively little *Calluna* and rather much *Gramineae*, *Cerealia*, *Rumex*, *Plantago* and *Cyperaceae*. For this reason it seems likely that the old arable below the tumuli 1 and 6 must have been abandoned a long time before the concerning barrows were raised, so that the heather could prevail over this arable land. The high *Salix* percentage in the old arable of tumulus 1 suggests that a *Salix* species—probably *Salix repens*—had settled on the abandoned arable plot. Only the arable below tumulus 4 must have been in use till a short time before the construction of the barrow.

Hunebeds and barrows near Diever (*Table VI*)

The results of the pollen analytical examination of some burial monuments in the vicinity of Diever are represented in Table VI.

For the *hunebed* (Passage Grave) D LII [1] near Diever a "sod"—a somewhat humous, dark spot in the otherwise rather clean sand of the *hunebed* mound—was analysed. The old surface was hardly perceptible, so that no reliable sample could be taken from it. The sod sample appeared to contain few pollen grains, so that it was not possible to count a sufficient amount of pollen in a reasonable time. As, moreover, the state of preservation was very bad, differential preservation will have changed the pollen content. The count of one sample yielded the following numbers of pollen: *Alnus* 4, *Betula* 1, *Corylus* 1, *Quercus* 2, *Tilia* 12, *Pinus* 1, *Calluna* 5, *Gramineae* 14, *Succisa* 1, *Dryopteris* 58, *Pteridium* 8, *Polypodium* 3.

In the mound of the destroyed *hunebed* near Wapse a trench was dug. Both the old surface and a dark-coloured sod—which was clearly outlined in the yellow sand of the mound—were sampled. The old surface sample appeared to contain no pollen, but the sod was fairly rich in well preserved pollen. The spectrum of this sample differs considerably from the other *hunebed* spectra. *Fagus* shows a value of 0.7 %, while also *Carpinus* occurs, and the *Calluna* percentage is high (144 %). At present it is not possible to give a plausible "explanation" of this remarkable result.

Stone cist barrow. In 1929 a barrow, the primary grave of which consisted of a so-called stone cist (dutch: *steenkist*) was excavated (Van Giffen, 1930). On account of the grave goods and the stone cist this barrow must be assigned to the latest phase of the *hunebed* culture. These indications of a Late Neolithic barrow agree with the fact that in the barrow, which consisted of dirty yellow sand, a number of clear sods could be distinguished, and that the subsoil showed a beginning podzolization.

In order to collect samples from this important barrow a trench was dug. In this trench some dark-coloured sods and the beginning podzolization were clearly visible.

A sample from the old surface and from a sod contained both abundant pollen grains in a good state of preservation. Both spectra show considerable agreement. The relatively high *Calluna* percentage (about 100 %) and the presence of *Fagus* are conspicuous. In the sod sample even a pollen grain of *Carpinus* was found. The values for *Gramineae*, *Rumex*, *Plantago* and *Compositae* are low.

This result is in striking contrast with that of Waterbolk (1954*b*) who found a typical "*landnam*" spectrum. It is not impossible that the sample analysed by Waterbolk—which was already collected in 1929—is not comparable with that from the old surface of this tumulus, but that this sample belongs to a secondary interment from the Beaker culture which had partly destroyed the primary grave. The sample in question was taken from a slightly humous spot in the primary grave.

Near this stone cist tumulus there is another barrow excavated by Van Giffen in 1931. The barrow had been built of light-coloured sods. The subsoil showed a beginning podzolization, *i.e.* a leached layer, about 10 cm thick, but not yet a hard pan.

A spectrum of a sod of this tumulus agrees in every respect with the spectra of the stone cist barrow. The resemblance is so great that not much time can have elapsed between the construction of both tumuli. On account of the sod structure and the type of the primary grave—a trunk coffin—this barrow has to be assigned to the Early

[1] For the numbering and description of the *hunebeds* we may refer to Van Giffen (1925–7).

Bronze Age. As the pollen spectrum of the stone cist barrow shows much similarity with that of the sod-built barrow, the stone cist

TABLE VI
Burial monuments in the vicinity of Diever

	hunebed Wapse	stone cist barrow old surface	stone cist barrow sod	sod-built barrow sod	Paasberg sod, prim. mound	Paasberg sod, capping
Alnus	52.0	45.5	47.8	51.7	68.5	64.2
Corylus	30.1	30.9	27.1	29.9	12.5	14.9
Quercus	9.3	19.3	16.4	15.4	13.2	15.2
Tilia	2.1	1.1	1.2	1.1	1.1	0.6
Ulmus	0.8	0.1	0.4	0.5	0.7	0.6
Fraxinus	0.4	0.4	0.5	0.1	0.4	0.6
Fagus	0.7	0.3	0.1	0.1	1.3	1.4
Carpinus	0.1	—	0.1	—	—	—
Pinus	4.1	2.4	3.9	1.0	2.0	2.0
Picea	—	—	—	0.1	—	—
Salix	0.2	—	—	—	—	—
Ilex	0.1	—	—	—	—	—
ΣAP—Betula	857	747	836	816	455	657
Betula	16.7	33.9	22.8	22.5	13.6	11.3
Myrica	0.1	—	—	—	—	0.3
Calluna	144	94.1	107	109	136	194
Gramineae	21.6	9.9	11.2	15.2	170	81.4
Cerealia	1.9	0.4	0.4	0.8	13.2	8.7
Plantago lanceolata	1.1	0.7	1.6	0.9	22.0	8.3
Rumex	1.1	2.8	1.4	0.9	14.1	14.2
Tubulifl. Compositae	0.9	0.7	0.1	—	2.9	3.2
Ligulifl. Compositae	2.4	0.3	1.7	1.0	7.7	3.2
Artemisia	0.5	0.1	0.6	0.4	0.9	0.8
Chenopodiaceae	0.2	—	—	—	1.5	1.5
Polygonum Persicaria	—	—	—	—	0.4	0.9
Spergula	—	—	—	—	—	4.0
cf. Spergularia	—	—	—	—	5.7	0.2
Caryophyllaceae	0.8	—	0.1	0.1	1.3	0.8
Rosaceae	—	—	—	—	0.2	0.3
Potentilla-type	—	—	—	0.1	—	0.5
Ranunculaceae	0.2	0.1	0.1	0.7	1.5	0.2
Umbelliferae	0.1	—	—	—	—	—
Campanulaceae	0.4	0.1	0.4	0.1	0.2	0.3
Galium-type	—	—	—	—	0.7	—
Mentha-type	—	—	—	—	0.4	0.5
Papilionaceae	—	—	—	—	0.2	—
Succisa	0.9	0.3	0.6	0.4	1.1	0.8
Cyperaceae	—	—	0.1	—	—	0.5
Sparganium	—	—	0.1	—	—	0.3
Dryopteris	11.7	2.6	4.2	5.1	7.7	5.0
Pteridium	4.1	1.5	1.2	3.9	2.6	3.3
Polypodium	9.4	0.1	0.1	—	0.2	—
Sphagnum	10.6	0.3	0.6	1.7	2.8	3.2

barrow must probably be placed about the transition from Neolithic time to Bronze Age.

Paasberg. The "Paasberg" near Diever, also excavated by VAN GIFFEN in 1931, had been built of fairly clear sods. A core of fairly dark-coloured sods and a capping of greyish sods could be distinguished.

The spectra of both constructional phases agree very well as far as the tree pollen is concerned. The low *Corylus* values and the fairly high *Fagus* percentages suggest that the "Paasberg" must have been constructed in the Early Iron Age (*cf.* the spectra of the barrows near Wijster, Table V).

The herbaceous percentages of both sods show rather great differences. The spectrum of the sample from the core has higher *Gramineae* and *Plantago* percentages and a lower *Calluna* percentage than that of the sod of the covering mound. In the first sample a pollen grain which in all probability has to be ascribed to *Spergularia* frequently occurred, while in the other sample *Spergula* was rather abundant.

Table VII represents the pollen spectra of some isolated burial monuments.

Hunebed Steenbergen, D I. The *hunebed* mound consisted of yellow sand, while the old surface could be recognized as a clear, dark-grey layer of about 10 cm thick. The sample from the old surface appeared to contain a small quantity of badly preserved pollen grains, so that differential preservation may have changed the pollen content.

Hunebed Exloo, D XXXI. The *hunebed* mound had been raised from yellow sand on a humous old surface, about 10 cm thick. The pollen was rather badly preserved.

The *Tilia* percentage in both *hunebed* samples is relatively high (8.5 and 6.6 %). *Fagus* and *Carpinus* do not occur. Attention is drawn to the occurrence of a pollen grain of *Viscum* in the sample from Exloo. In the sample from Steenbergen the *Calluna* value is rather low, and that for *Gramineae* fairly high. *Calluna* is more abundant in the sample from Exloo. In the sample from Steenbergen *Plantago* is scarce, and is even lacking in the sample from Exloo. This last sample shows relatively high values for *Liguliflorae*, *Artemisia* and *Caryophyllaceae*.

Galgenberg near Ruinen. A three-period barrow, consisting of:
A primary mound of brownish-grey sand on a hardly perceptible old surface of washed-out gravel. Beaker Culture, Late Neolithic (*cf.* GLASBERGEN, 1954).
A second and third period equally of sand without sods.

The old surface of the primary mound contained—contrary to expectation—a fairly large amount of pollen grains in a rather good state of preservation. This sample shows a typical "*landnam*" spectrum, viz. fairly much *Plantago*, *Rumex*, *Compositae*, *Gramineae* and *Dryopteris*. *Fagus* does not occur. In the sample from the second period *Fagus* is present, whilst the values for *Rumex*, *Plantago* and *Gramineae* have greatly decreased. It is striking that the *Calluna* percentage of the capping is not noticeably higher than that of the primary mound.

TABLE VII
Various isolated burial monuments

	hunebed D I Steenbergen	hunebed D XXXI Exloo	Galgenberg near Ruinen period 1	Galgenberg near Ruinen period 2	Galgenberg near Ruinen period 3	Oudemolen tumulus 13 old surface	Oudemolen tumulus 13 sod, period 2	Oudemolen tumulus 13 sod, period 3	tumulus near Schoonloo	Eext tumulus 2
Alnus	61.5	43.3	57.3	59.1	24.7	55.6	51.9	53.5	55.9	57.7
Corylus	25.2	34.1	29.1	33.0	35.1	30.1	28.0	26.0	36.1	22.9
Quercus	3.4	11.5	11.0	4.1	34.9	11.1	16.1	12.7	4.3	12.9
Tilia	8.5	6.6	1.9	1.0	0.3	0.8	0.8	0.3	0.8	1.2
Ulmus	0.3	0.2	0.1	0.4	0.2	0.6	0.7	0.9	0.4	0.2
Fraxinus	0.3	0.8	0.4	0.3	—	0.5	0.2	0.1	0.2	0.1
Fagus	—	—	—	0.4	2.7	0.2	0.4	1.7	0.1	3.5
Carpinus	—	—	—	—	0.8	—	—	0.1	—	0.1
Pinus	0.3	2.7	0.2	1.8	1.2	1.1	1.7	4.5	2.1	1.2
Picea	—	—	—	—	—	—	0.1	—	—	—
Salix	0.7	0.4	—	—	0.2	—	—	—	—	—
Hedera	—	0.2	—	—	—	—	—	—	—	—
Viscum	—	0.2	—	—	—	—	—	—	—	—
ΣAP—Betula	294	487	829	782	639	876	845	866	923	946
Betula	7.5	25.3	20.6	7.5	16.2	14.1	18.3	15.2	8.3	5.8
Humulus	—	—	—	—	—	—	—	0.1	—	—
Myrica	—	—	—	—	—	—	—	—	—	0.1
Calluna	20.7	55.2	33.7	36.3	162	123	93.7	230	95.2	132
Gramineae	37.4	16.0	64.9	26.8	31.1	23.5	10.7	7.0	10.7	16.5
Cerealia	—	—	1.7	3.6	7.5	1.9	0.7	0.5	0.1	0.7
Plantago lanceolata	1.0	—	9.3	4.0	0.8	1.0	1.3	0.5	0.2	4.0
Rumex	2.0	2.7	6.1	0.4	1.9	3.5	0.4	0.3	0.9	0.5
Tubulifl. Compositae	1.4	1.2	3.9	0.9	0.6	0.8	—	0.1	0.2	0.4
Ligulifl. Compositae	4.4	14.6	6.3	4.4	2.3	3.5	0.2	0.2	—	3.5
Artemisia	—	2.7	0.1	0.3	—	0.1	—	—	0.2	—
Cyperaceae	0.4	2.0	0.1	—	0.9	—	—	—	0.5	—
Caryophyllaceae	0.3	4.5	1.1	1.9	—	0.5	—	0.1	0.1	0.5
Spergula	—	0.2	—	—	0.3	—	—	—	—	—
Succisa	1.4	0.2	1.7	0.4	0.2	0.9	—	1.2	—	2.9
Chenopodiaceae	—	—	0.2	0.3	—	0.2	—	0.4	—	0.3
Polygonum Persicaria	—	—	—	—	—	—	—	—	—	0.1
Ranunculaceae	—	0.6	0.4	0.3	0.3	0.1	0.1	0.1	—	0.6
Potentilla-type	—	0.4	—	—	0.2	—	0.1	—	—	—
Galium-type	0.3	—	—	0.1	0.2	—	—	—	—	—
Umbelliferae	—	0.2	—	—	0.6	—	—	—	—	—
Campanulaceae	—	1.8	—	0.1	—	—	—	—	—	—
Valeriana	—	—	—	—	0.2	0.1	—	—	—	—
Frangula	—	—	—	—	0.3	—	—	—	—	—
Mentha-type	—	—	0.1	—	—	—	—	—	—	—
Dryopteris	106	3.1	23.9	10.9	5.0	5.4	2.4	1.3	1.7	6.0
Polypodium	3.4	—	0.1	0.6	—	0.1	—	0.1	0.1	0.2
Pteridium	7.5	0.2	6.5	300	5.2	3.7	2.6	1.4	0.9	1.5
Dryopteris Linnaeana	0.3	—	—	—	—	—	—	—	—	—
Lycopodium cf. clavatum	0.7	—	—	0.1	—	—	—	—	—	—
Sphagnum	41.5	1.0	4.0	5.0	11.7	1.3	0.5	0.9	0.5	6.6

In view of the *Fagus* percentage (2.7 %) and the *Carpinus* value of 0.8 % the last capping (period 3) has to be placed in the Early Iron Age, although the *Corylus* value (35.1 %) is very high for a spectrum from that time. The *Calluna* percentage—compared with that of the preceding periods—shows a sharp rise, indicating an expansion of the heather.

Tumulus 13 near Oudemolen. This tumulus which joins the barrow cemetery near Oudemolen (pollen analytical investigation by WATERBOLK, 1954*b*) consisted of three periods. The primary mound of dirty yellow sand had been raised on a humous old surface. The second period was a capping of rather clear, long sods, whilst in the third period only a few sods could be observed.

The spectrum of the old surface of the primary barrow shows much resemblance to that of the first period of tumulus 12 (WATERBOLK, 1954*b*). The primary mound of that tumulus had been built of yellow sand with some long sods on a subsoil with some accumulation of humus. Although in the primary mound of tumulus 13 no sods could be distinguished, the structural resemblance to tumulus 12 is great, whilst moreover in both cases the primary grave contained a trunk coffin. A ^{14}C-measurement of a charcoal sample from the primary grave by Professor HL. DE VRIES at Groningen gave a dating of 1550 ± 125 B.C.

With regard to the spectrum of the old surface it may be noted that *Fagus* is present already. In contrast with most spectra of Neolithic barrows the values for *Gramineae*, *Plantago* and *Compositae* are relatively low, while that for *Calluna* is high. The spectrum of a sod of the second period shows much resemblance to that of the first period. It is remarkable that the *Calluna* percentage of this period is lower than that of the primary mound. The spectrum of a sod of the third period shows some marked differences with the spectra of the preceding periods. *Fagus* has increased (from 0.3 to 1.7 %), just as *Calluna*. The *Corylus* percentage is not markedly lower than that of the other periods. For that reason it seems likely that the third period still must be assigned to the Late Bronze Age (*cf.* tumulus 12, periods 3 and 4).

Barrow with stone revetment near Schoonloo. This was a partly destroyed, sod-built barrow with a clearly podzolized subsoil. As the central part of this barrow had been heavily damaged, the primary grave could no longer be recognized. The presence of a stone revetment around the barrow has to be mentioned.

The spectrum of the old surface is not characteristic. The value for *Corylus* is high, whilst that for *Quercus* is low. *Fagus* occurs in a very low percentage, whilst also the pollen of cultivation shows low values.

Tumuli near Eext. In 1952 two tumuli near Eext were excavated. Both barrows showed a considerable similarity. Only the old surface of tumulus 2 was more dark-coloured than that of tumulus 1. The barrows had been built of light-coloured sods on a faintly podzolized subsoil.

Only the old surface of tumulus 2 appeared to contain a sufficient amount of well preserved pollen grains. Concerning this spectrum it must be mentioned that the *Fagus* value is fairly high (3.5 %), whilst *Carpinus* is also present. The *Fagus* and *Carpinus* percentages suggest that this tumulus must have been built in the Early Iron Age.

Trackways near Emmererfscheidenveen. During the very intensive exploitation of the raised bog near Emmererfscheidenveen two trackways—both lying in the Younger *Sphagnum* peat—were brought to light. One trackway showed a very simple construction, namely longitudinally laid rods, of birch among others. This track was

not excavated, so that only its cross-section in the peat profile could be observed. The other trackway had been built of oak planks. In 1952 a part of this trackway was excavated. It appeared, however, that the excavated part had been destroyed at an earlier date in order to interrupt the communication. As far as that could be examined this trackway had been constructed of successive pairs of planks which had been laid longitudinally side by side. These planks, about 30 cm in width, were supported by transverse planks. Both ends of every transverse beam were perforated by a square-cut mortise hole, through which a sharpened vertical stake had been driven into the peat, so that in this way the track was held in place.

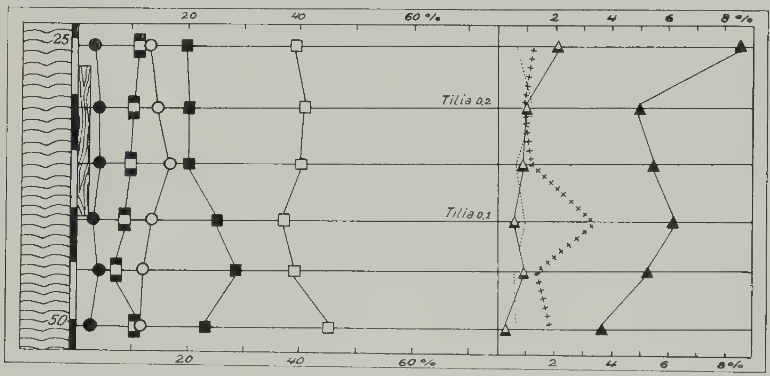

Fig. 15. Pollen analytical position of the trackway of longitudinally laid rods near Emmererfscheidenveen.

In Fig. 15 the position of the first trackway is indicated. The *Corylus* value is low, whilst *Tilia* occurs irregularly. In the middle part of the diagram *Carpinus* shows a value of about 1 %, while that for *Fagus* is about 5 %. The fact that in the upper spectrum, which lies just above the trackway, *Carpinus* increases could suggest that this is the beginning of the second increase of *Carpinus*. In the lower part of the diagram the first increase of *Carpinus* is just visible. Therefore the trackway must have been constructed after 200 A.D. It is likely that this track dates from the 4th to 6th century A.D.

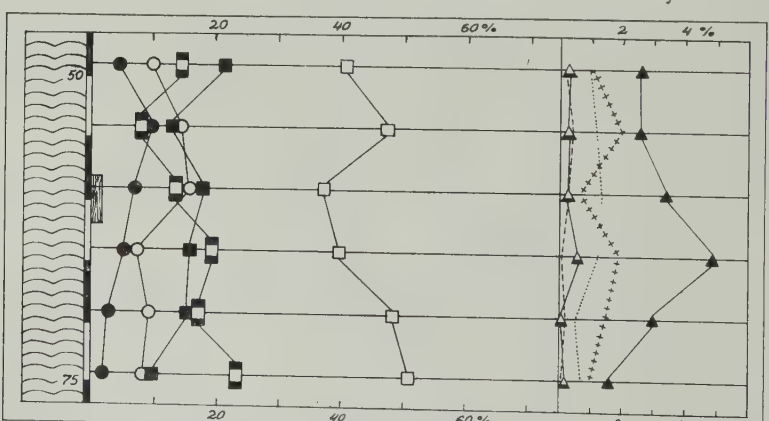

Fig. 16. Pollen analytical position of the trackway built of planks near Emmererfscheidenveen.

The position of the other trackway is indicated in Fig. 16. *Tilia* still occurs throughout the diagram. *Corylus* shows a decrease which corresponds with the final fall in the *Corylus* curve. In this diagram the decline of *Corylus* is likewise accompanied by a rise of *Fagus*. The rather low *Fagus* percentages in the upper spectra of the diagram are somewhat remarkable. The first increase of *Carpinus* is not yet present in this diagram. On the ground of the position in the pollen diagram this trackway must probably have been constructed in the first or second century B.C.

VI. THE POLLEN ANALYTICAL POSITION OF THE SO-CALLED *GRENZHORIZONT*

The most conspicuous phenomenon in the stratigraphy of the raised bogs from western Europe is the so-called *Grenzhorizont* the first time described by WEBER (1900). This contact surface constitutes the border between the dark-coloured, highly humified Older *Sphagnum* peat and the overlying, light-coloured, fresh Younger *Sphagnum* peat.[1] WEBER (1910, 1926, 1930) assumed that originally the Older *Sphagnum* peat had the same appearance as the Younger *Sphagnum* peat, but that during a dry time, the Subboreal period, this peat got its present high degree of humification. According to WEBER peat formation came to a standstill during that dry time, and the surface of the raised bog was covered with a vegetation of *Calluna* and *Eriophorum*. Later on, when the climate became more humid, in the Subatlantic time, the formation of Younger *Sphagnum* peat would have started, beginning at the borders of the raised bogs. Much time would have elapsed between the ceasing of the growth of the Older *Sphagnum* peat and the beginning of the growth of the Younger *Sphagnum* peat. WEBER assumed a period of at least 1000 years. He accepted the post-glacial climatic scheme of BLYTT/SERNANDER which distinguishes a dry Boreal, a wet Atlantic, a dry Subboreal and a wet Subatlantic time, since SERNANDER (1908) already had equalized the Younger *Sphagnum* peat with the Subatlantic time and the *Grenzhorizont* with the Subboreal time.

WEBER (1926, 1930) dated the beginning of the growth of the Younger *Sphagnum* peat between 1000 and 750 B.C. This dating was based on the discovery of a peat burial ("*Moorleiche*"). In 1895 in the "Wolfsbrucher Moor" near Obenaltendorf (Kreis Kehdingen) a peat burial was discovered in the Younger *Sphagnum* peat at 150 cm below the surface. Through the presence of grave goods this peat burial could be dated in the 4th century A.D. From that time till the middle of the 19th century—when on account of drainage peat formation came to an end—150 cm fresh *Sphagnum* peat had been formed, that is 1 m per 1000 years. The greatest thickness of the Younger

[1] The Older *Sphagnum* peat not being always older than the Younger *Sphagnum* peat—as will be demonstrated—these terms only indicate humified and fresh *Sphagnum* peat respectively.

Sphagnum peat in the "Wolfsbrucher Moor" was nearly 3 m. From this WEBER concluded that the formation of Younger *Sphagnum* peat must have started between 1000 and 750 B.C.

It must once more be pointed out that, according to WEBER, the formation of Younger *Sphagnum* peat in a single raised bog did not start everywhere at the same time, but that after the Subboreal period of standstill the formation of this type of peat started at the borders, whereas at the centre of the raised bog the formation of fresh *Sphagnum* peat did not take place until later. On the other hand, it has been supposed by most west European peat investigators after WEBER that the formation of fresh *Sphagnum* peat started everywhere at the same time, so that the beginning of the formation of Younger *Sphagnum* peat would be a synchronous phenomenon.

WEBER's idea that during a long period peat formation did not take place, and that the high degree of humification of the Older *Sphagnum* peat would be a secondary phenomenon, was soon abandoned by nearly all investigators. As the chief argument against a long period of standstill SCHROEDER (1930) puts forward that in the pollen diagrams from the raised bogs near Worpswede the pollen lines do not show interruptions at the transition from Older to Younger *Sphagnum* peat. This uninterrupted course of the curves is clearly shown in the so-called "*Lupendiagramm*" from Bergedorf, equally near Worpswede. According to GROSS (1930) and OVERBECK and SCHMITZ (1931) the difference in humification must be ascribed to a difference in climate effecting a different rate of decay during the peat formation.

The dating of the beginning of the growth of the Younger *Sphagnum* peat according to WEBER was confirmed by SCHUBERT (1933). This author sampled a profile near the spot where the peat burial was discovered. At the removal of the dead body, present in the museum at Stade, also a sod of peat showing the cast of a piece of fabric pertaining to the peat burial was collected. SCHUBERT analysed the peat profile and fitted the spectrum of the sod into the diagram. He arrived at the conclusion that the *Grenzhorizont* has to be dated between 1000 and 750 B.C.

One gets the impression that WEBER's dating was accepted as too firm a fact to raise objections against. In examining other finds from bogs it was too easily accepted that this dating of the *Grenzhorizont* was correct. On that account various objects—especially trackways and peat burials—which lay just above or below the *Grenzhorizont* were dated too early, *e.g.* the peat burial from the bog near Veerssen (KOCH, 1934*b*), the trackway from the "Wittmoor" (HALLIK, 1949) and some trackways from the raised bog near Diepholz (PFAFFENBERG, 1936).

After synchronizing the *Grenzhorizont* with the RY III of GRANLUND (1932) a dating of 500–600 B.C. is fairly generally accepted for this contact surface.

In Swedish raised bogs not one, but a number of contact surfaces between more and less humified *Sphagnum* peat can be recognized (GRANLUND, 1932; LUNDQUIST,

1932). These so-called recurrence surfaces have been dated with the help of archaeological finds. The following contact surfaces are distinguished:

RY I	about	1200 A.D.		RY V	about	2300 B.C.
RY II	,,	400 A.D.		RY VI	,,	2800 B.C.
RY III	,,	600 B.C.		RY VII	,,	3700 B.C.
RY IV	,,	1200 B.C.				

In north-west European raised bogs generally one distinct contact surface, the *Grenzhorizont*, can be distinguished. Overbeck and Schneider (1938) pointed out already that even in a single raised bog the *Grenzhorizont* must not be considered too much as a fixed point of time, and that the dating of the *Grenz* in the various regions is yet far from certain. In later years this opinion was underlined by Overbeck (1952) once again. Overbeck and collaborators, however, maintain—in spite of the labile character—the *Grenzhorizont* as the border between the Subboreal and Subatlantic time.

As a result of an archaeological and pollen analytical investigation of the "Bolleveen" near Zeijen Waterbolk (1950) and Van Giffen (1947, 1950) arrived at another dating of the *Grenzhorizont*. This investigation has already been discussed on p. 31. As in this small raised bog the formation of fresh *Sphagnum* peat started at about 400 A.D. the *Grenzhorizont* would here be synchronous with the RY II of Granlund. On the ground of a comparison of the "Bolleveen" diagram with the diagrams from large raised bogs Waterbolk concluded that in general the *Grenzhorizont* would not be synchronous with the RY III, but with the RY II, and that consequently the beginning of the growth of the Younger *Sphagnum* peat has to be dated at about 400 A.D.

Nilsson (1948) arrived at a completely different conclusion. This investigator compared diagrams from north-west Germany and the Netherlands with those from Sweden, and concluded that the *Grenzhorizont* not always coincides with the RY III. There would be, however, raised bogs in which the *Grenzhorizont* corresponds with one of the other recurrence surfaces. In the Netherlands and in north-west Germany the formation of the Younger *Sphagnum* peat could have started at the following times: about 400 A.D., about the beginning of the era, about 500 B.C., about 1200 B.C. and about 2300 B.C. Schmitz (1952) is of the same opinion. Although, according to this author, in north-west Germany the transition from highly humified to fresh *Sphagnum* peat in general would correspond with the RY III, there would also occur raised bogs in which this transition is synchronous with one of the other Swedish recurrence surfaces.

According to Bennema (1954) it seems likely that the beginning of the growth of the fresh *Sphagnum* peat was not a synchronous phenomenon, as it was local conditions that effected the transition from highly humified to fresh *Sphagnum* peat.

In order to get an impression of the behaviour of the *Grenzhorizont* [1]

[1] The name *Grenzhorizont* is used here for the contact surface between highly humified and fresh *Sphagnum* peat, independent of the dating. This in contrast

in a single raised bog an investigation was carried out into the pollen analytical position of the *Grenz* in the raised bog near Emmererfscheidenveen. It is for this reason that from this raised bog, besides a complete profile (*cf.* Chapter III), at various sites the peat section below and above the *Grenzhorizont* was sampled and analysed. For the sake of surveyability only the stratigraphy and the curves for the more important trees are represented in these diagrams, because the curves for species as *Salix*, *Acer* and others, just as those for the herbaceous types, are not of importance for this purpose.

Not unfrequently a so-called "*Vorlaufstorf*", a *Sphagnum cuspidatum* peat layer, is present. This type of peat overlies directly the highly humified *Sphagnum* peat, without a transitional layer. The structure of this easily fissile *Sphagnum cuspidatum* peat differs greatly from the fresh, sponge *Sphagnum imbricatum* and *papillosum* peat. On account of the low degree of humification this type of peat is assigned to the Younger *Sphagnum* peat (Weber in Jonas, 1933). The contact surface of this "*Vorlaufstorf*" with the highly humified *Sphagnum* peat thus constitutes the *Grenzhorizont*.

It is true that in the profile of diagram A (Fig. 17) a 24 cm thick layer of humified *Sphagnum* peat is present on top of the *Sphagnum cuspidatum* layer. A comparison with *e.g.* profile B, where only a 5 cm thick layer of humified peat overlies the "*Vorlaufstorf*", suggests that it is justifiable to place the *Grenzhorizont* in the profile A at a depth of 106 cm. In the diagrams from the raised bog near Gifhorn (Overbeck, 1952) there is a similar layer of humified *Sphagnum* peat on top of the *Sphagnum cuspidatum* peat.

STRATIGRAPHY

Diagram A

45– 61	cm	fresh *Sphagnum imbricatum* peat
61– 66	,,	fresh *Sphagnum papillosum* peat
66– 90	,,	highly humified *Sphagnum* peat with remains of *Ericaceae* and *Eriophorum*
90–106	,,	fresh *Sphagnum cuspidatum* peat with remains of *Eriophorum* and leaves of *Andromeda*
106–115	,,	highly humified *Sphagnum* peat with remains of *Ericaceae*

Diagram B

60– 75	cm	fresh *Sphagnum papillosum* peat
75– 80	,,	highly humified *Sphagnum* peat with remains of *Ericaceae* and *Eriophorum*
80– 99	,,	fresh *Sphagnum cuspidatum* peat with remains of *Eriophorum* and leaves of *Andromeda*
99–110	,,	highly humified *Sphagnum* peat with remains of *Ericaceae*

with Overbeck (1952) and Schmitz (1952) who proposed to confine that name to the contact surface which can be dated at about 500 B.C.

Diagram C

80– 92	cm	fresh *Sphagnum cuspidatum* peat with remains of *Eriophorum*
92–105	,,	highly humified *Sphagnum* peat with remains of *Ericaceae* and *Eriophorum*

N.B. Above a depth of 80 cm the peat had already been cut away.

Diagram D

70– 80	cm	fresh *Sphagnum papillosum* peat
80– 89	,,	fresh *Sphagnum cuspidatum* peat
89–100	,,	highly humified *Sphagnum* peat with remains of *Ericaceae*

Diagram E

75– 80	cm	fresh *Sphagnum papillosum* peat
80– 85	,,	fresh *Sphagnum cuspidatum* peat with some *Sphagnum papillosum*
85– 99	,,	fresh *Sphagnum cuspidatum* peat with remains of *Eriophorum* and leaves of *Andromeda*
99–105	,,	highly humified *Sphagnum* peat with remains of *Ericaceae* and *Eriophorum*

Diagram F

20– 30	cm	fresh *Sphagnum papillosum* peat
30– 50	,,	*Eriophorum* peat with remains of fresh *Sphagnum papillosum*
50– 56	,,	highly humified *Sphagnum* peat with remains of *Eriophorum*
56– 80	,,	highly humified *Sphagnum* peat with remains of *Ericaceae*

Diagram G

15– 27	cm	fresh *Sphagnum imbricatum* and *papillosum* peat
27– 28	,,	fresh *Sphagnum cuspidatum* peat
28– 45	,,	highly humified *Sphagnum* peat with remains of *Ericaceae* and *Eriophorum*

A comparison of the diagrams A to G (Figs. 17–23) shows that they are not quite identical. Especially the *Quercus* percentages vary greatly in the various diagrams. This phenomenon suggests that the pollen rain at the various sites of the raised bog was not the same. As the forest vegetation in the vicinity of the raised bog will have varied dependent on local factors the position of a given part of the bog in respect to the higher sandy soils was of much importance for the pollen rain on the spot. On this account more attention must be paid to the general course of the curves and the presence of characteristic points than to the absolute percentages. It then appears that the diagrams are quite well comparable.

Diagram A (Fig. 17) forms part of the diagram from Emmer-erfscheidenveen discussed in Chapter III. For a more detailed comparison with the other diagrams from this region a sample distance of 5 cm appeared in general yet too large, so that a number of intermediate samples was analysed. In the lower part of diagram A the *Fagus* percentages are very low (0.2–0.4 %). At a depth of 100 cm *Fagus* shows a somewhat higher value (about 1 %). The same increase of *Fagus* can also be observed in the diagrams B and C (Figs. 18 and 19). The other diagrams start at a point where *Fagus* has reached already these somewhat higher values. In diagram A *Fagus* rises regularly

from a depth of 85 cm in order to reach a value of 5 % at a depth of 59 cm. In the other diagrams this rise in the *Fagus* curve sometimes shows small irregularities. It has already been noted that the last *Corylus* maximum (C_4) coincides with the point whence *Fagus* starts to increase. In the other diagrams from this raised bog this coincidence

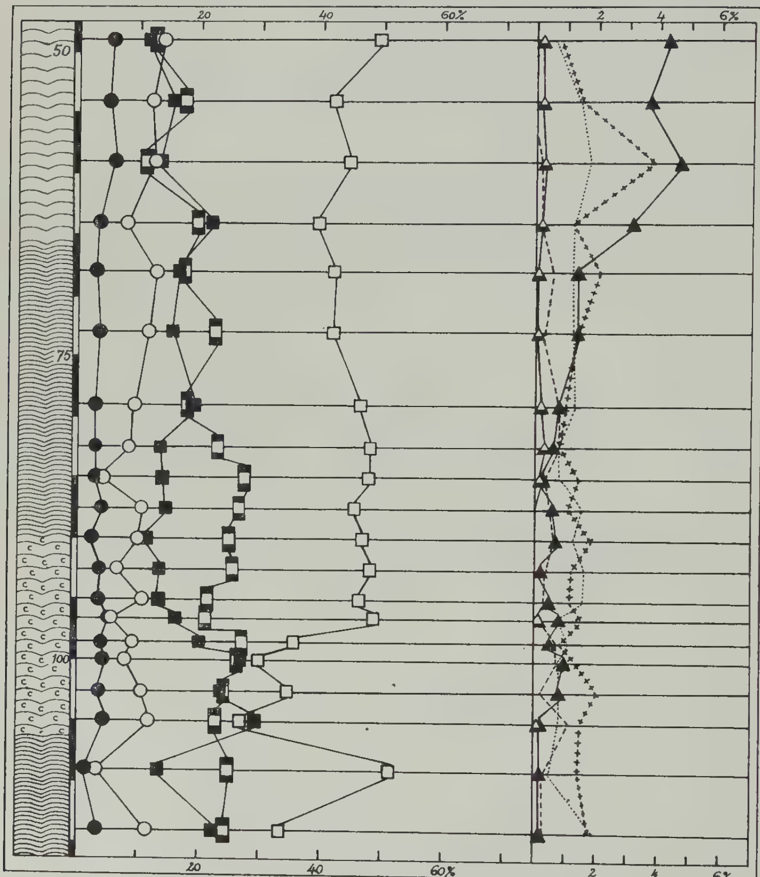

Fig. 17. Emmererfscheidenveen A.

is always clearly shown. The end of the expansion of *Fagus* is always coupled with a *Fraxinus* maximum.

Concerning the course of the *Corylus* curve in the diagrams from Emmererfscheidenveen it is useful to compare these diagrams with that from Bargeroosterveld (Fig. 9). In that diagram—just as in that from Roswinkel—the *Corylus* curve shows some fluctuations not present in diagram A. These fluctuations are of importance for a correct interpretation of the position of the *Grenzhorizont* in the diagrams D and E (Figs. 20 and 21). In the diagram from Bargeroosterveld a *Corylus* minimum is seen at a depth of 82 cm, which minimum in the diagrams A, B and C is present at a depth of 96, 96 and 91 cm

respectively. This minimum is followed by a sudden rise, likewise present in the diagrams A, B and C. Before reaching the last maximum the *Corylus* curve shows another minimum at a depth of 74.5 cm in the Bargeroosterveld diagram. This minimum is not shown in the diagrams A and B. In the upper part of diagram C this minimum can just be seen. The course of the *Corylus* curve in diagram D is well comparable with that in the Bargeroosterveld diagram. The spectrum at a depth of 95 cm corresponds with that at a depth of 79.5 cm in the diagram from Bargeroosterveld. In the diagrams D and E the *Corylus* minimum immediately below the C_4 is present at a depth of 88 and 104 cm respectively. The different rate of peat formation at

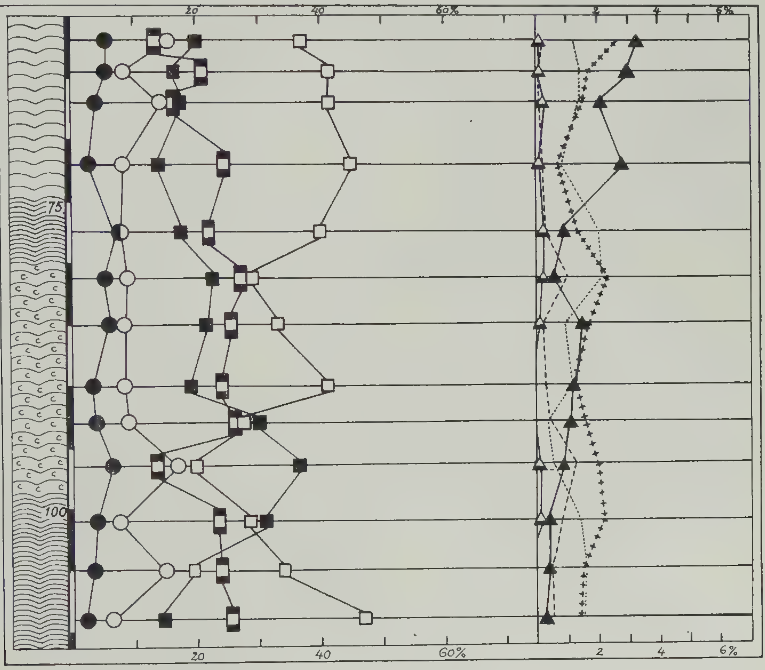

Fig. 18. Emmererfscheidenveen B.

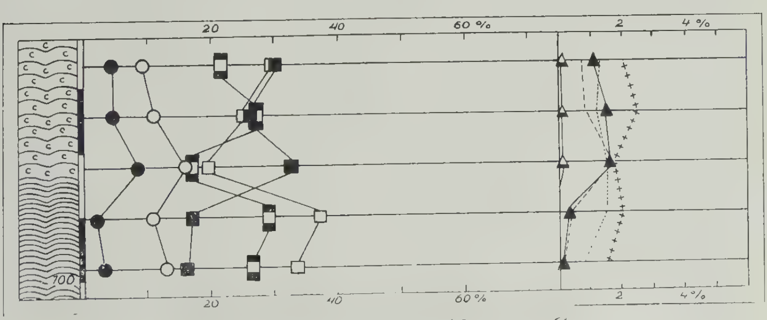

Fig. 19. Emmererfscheidenveen C.

the various sites of a raised bog is again clearly presented in these profiles. For a correct comparison of the diagrams D and E with diagram A the Bargeroosterveld diagram is thus very useful, as otherwise the *Corylus* minimum in the diagrams D and E could have been

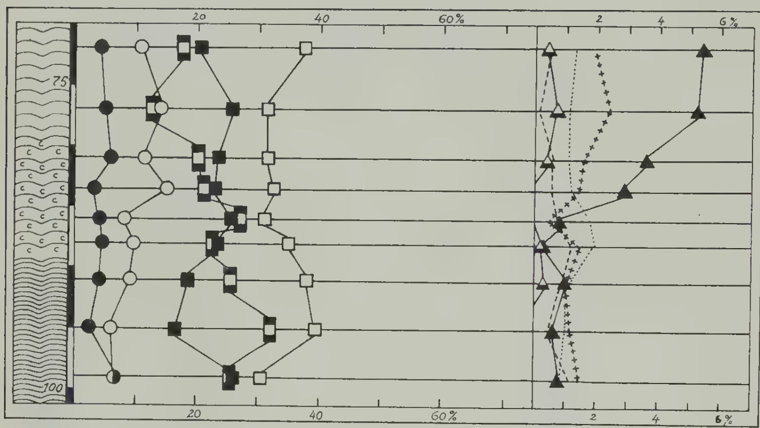

Fig. 20. Emmererfscheidenveen D.

easily equalized with the *Corylus* minimum at a depth of 96 cm in diagram A.

When we examine the position of the *Grenzhorizont* in the various profiles the result is the following: In diagram A this contact surface lies at a depth of 106 cm, below the first, small increase in the *Fagus* curve, while in diagram B this contact surface lies somewhat higher, immediately above the increase in the *Fagus* curve. The position of the *Grenzhorizont* in diagram C coincides with that in diagram B.

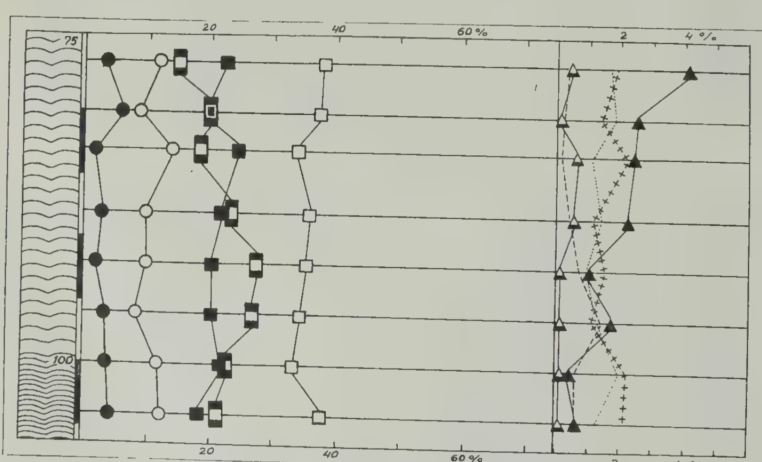

Fig. 21. Emmererfscheidenveen E.

In diagram D the *Grenz* corresponds with the *Corylus* minimum preceding the last *Corylus* maximum. In diagram E this contact surface lies somewhat higher, just below the last *Corylus* maximum. In diagram F no distinct contact surface was present. From 50 cm downwards the peat consisted of highly humified *Sphagnum* peat, whereas the

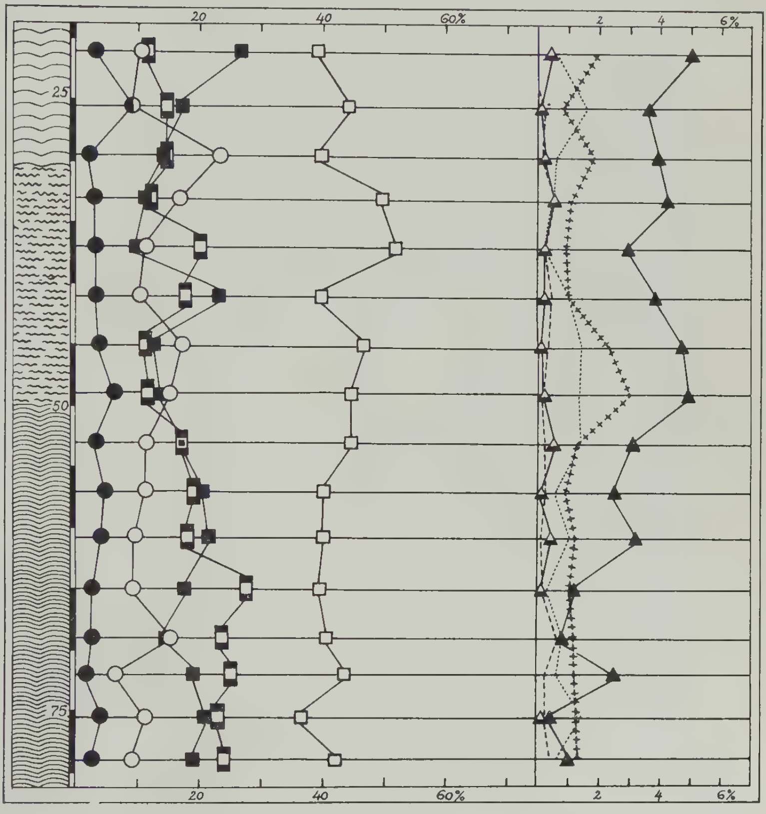

Fig. 22. Emmererfscheidenveen F.

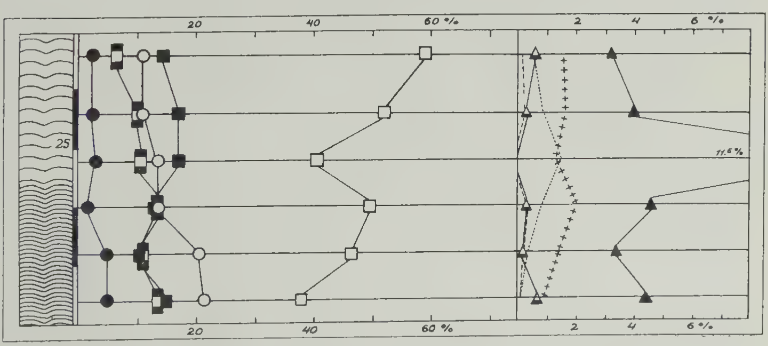

Fig. 23. Emmererfscheidenveen G.

layer between 30 and 50 cm was composed of *Eriophorum* peat with remains of fresh *Sphagnum* papillosum. For this reason the beginning of the formation of fresh *Sphagnum* peat is placed at a depth of 50 cm, that is just below the end of the expansion of *Fagus*. In diagram G the transition in question falls even much later.

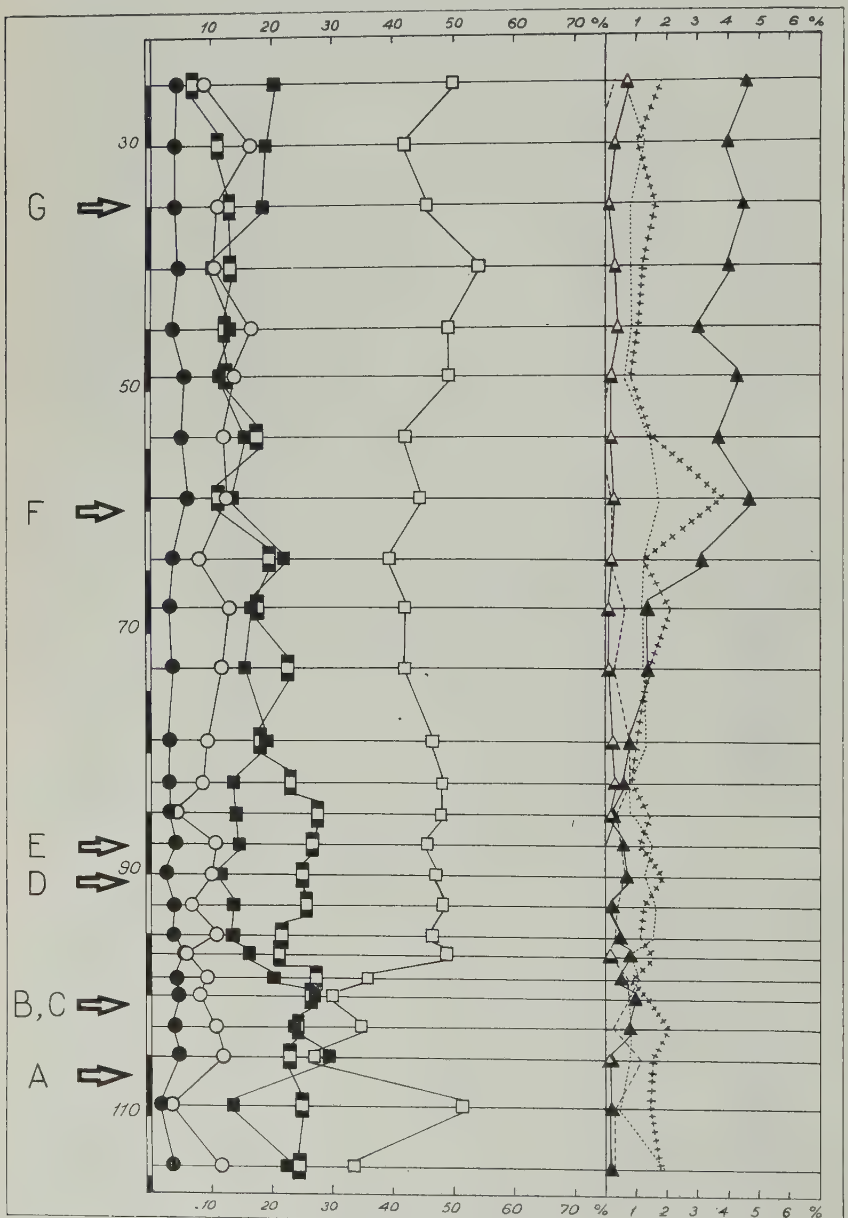

Fig. 24. In this diagram the position of the *Grenzhorizont* in the profiles of the diagrams Emmererfscheidenveen A–G is indicated by means of arrows.

In Fig. 24 the position of the *Grenzhorizont* in the various profiles from Emmererfscheidenveen is indicated in one diagram. As has already been noted the *Corylus* minimum just below the last *Corylus* maximum is not present in diagram A, to which the position of the *Grenzhorizont* in the other profiles is transferred. This *Corylus* minimum has been equalized with the spectrum at a depth of 90 cm. In this way it is clear once again that the contact surface in the various profiles is not synchronous. The diagrams F and G show the latest contact surface. The spots where these two profiles were sampled lie comparatively near the border of the raised bog.

If one prefers to leave the *Grenzhorizont* in profile A out of consideration on account of the 24 cm thick layer of humified *Sphagnum* peat on top of the *Sphagnum cuspidatum* peat, this will not alter the fact that even in a single raised bog the transition from highly humified to fresh *Sphagnum* peat is not a synchronous phenomenon. It appears thus that while on one spot formation of fresh *Sphagnum* peat took place, on another spot in the same raised bog still typical Older *Sphagnum* peat was formed.

The phenomenon discussed above is not confined to the raised bog from south-east Drente, but in various papers in which some diagrams from a single raised bog have been published the same behaviour of the *Grenzhorizont* can be seen. It is in this connection that in the first place the investigation of Jonas (1933) in the "Wilde Moor" near Papenburg has to be mentioned. In the diagrams Jonas gives from the *Sphagnum cuspidatum* layer in various profiles from that raised bog it is clear that the contact surface between Older and Younger *Sphagnum* peat in those profiles cannot be synchronous, a phenomenon to which Jonas already has drawn attention.

This unstable position of the *Grenzhorizont* is also very clear in the diagrams from the raised bog near Vriezenveen (Florschütz and Wassink, 1935). Especially in the diagram from the border zone of that raised bog the transition from highly humified to fresh *Sphagnum* peat falls—in view of the relatively high *Fagus* and *Carpinus* percentages—distinctly later than in the other diagrams.

The various profiles from the "Fresenburgsmoor" (Schubert, 1933) show a different pollen analytical position of the *Grenz*.

In one diagram from the raised bogs near Worpswede (Schroeder, 1930), namely the diagram "Worpswede", the *Grenzhorizont* must fall much later than in the other diagrams from that region. Schroeder ascribed the high *Fagus* percentage at the level of the contact surface to an early occurrence of *Fagus* on the sand isle "Weyer Berg" on the lee-side of the profile in question. In addition to the course of the *Fagus* curve that of the other curves also points to a late contact surface in this profile, compared with the other profiles from the raised bogs near Worpswede.

In both diagrams from the raised bog near Oldenbrook (Overbeck and Schmitz, 1931) the contact surface does not correspond with the same pollen analytical horizon. In one diagram the contact

surface lies below the first increase of *Carpinus*, whereas in a second diagram this transition corresponds with a level at some distance above the first increase of *Carpinus*.

Finally Overbeck and Schneider (1938) already pointed out the irregularity in the position of the contact surface in the various profiles from the raised bog near Melbeck.

In the raised bogs mentioned above the same phenomenon as in the raised bog from south-east Drente can be observed, viz. that the contact surface between highly humified and fresh *Sphagnum* peat is not synchronous in the various parts of the same raised bog.

As in a single raised bog the *Grenzhorizont* can be formed at various times, it is not to be wondered at that a comparison of the pollen

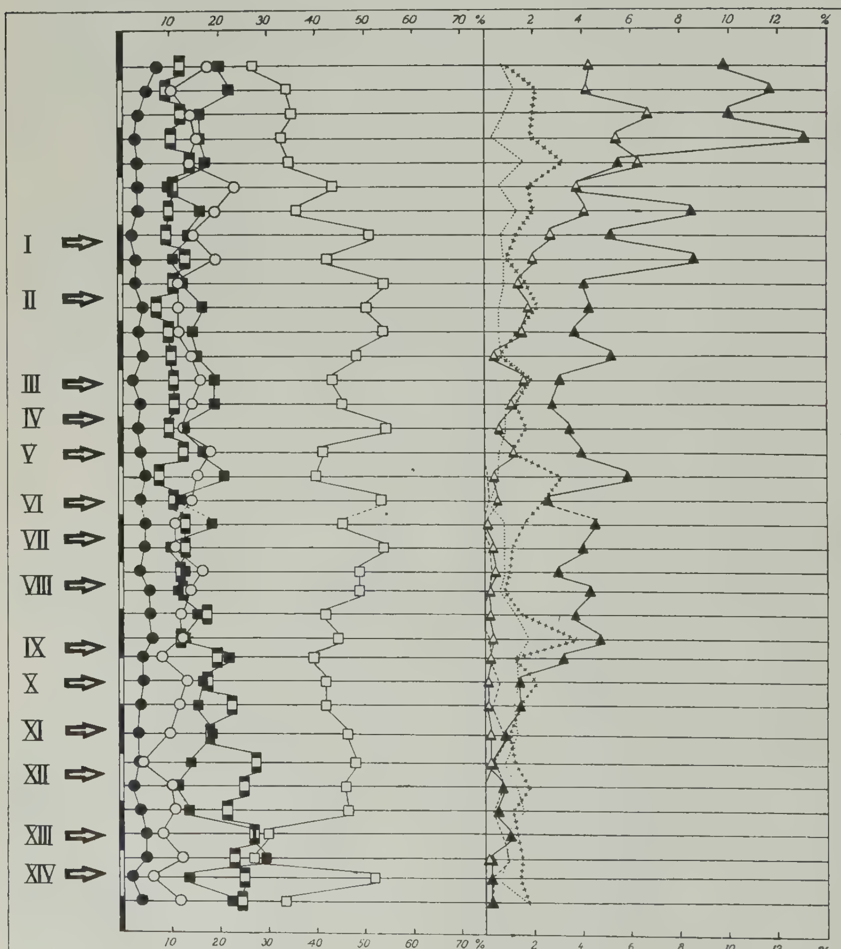

Fig. 25. In this diagram the position is indicated of the *Grenzhorizont* in the profiles summed up on the opposite page. The Roman figures left of the diagram correspond with those of the profiles.

analytical position of the *Grenzhorizont* in the various raised bogs shows great mutual differences. In order to illustrate this the pollen analytical position of the transition from highly humified to fresh *Sphagnum* peat in a number of profiles from north-west Germany and the Netherlands is indicated in Fig. 25. The diagram, to which the position of the *Grenzhorizont* in the various profiles is transferred, is composed of the upper part of the Emmererfscheidenveen I diagram and the upper part of the Fochteloo diagram. As in the earlier diagrams in general the sample distance is rather great (15–25 cm), it is not always possible to determine the pollen analytical position of the *Grenzhorizont* in the concerning profiles as exactly as desired. A second source of error lies in the fact that the diagram of Fig. 25 cannot be compared in all details with the diagrams summed up below, whilst in the third place the number of pollen grains counted in each sample is rather low in most of the earlier diagrams. Various irregularities in the curves, particularly for the less abundant pollen types, of those diagrams will undoubtedly be due to this small number of pollen grains counted.

For the transferring of the position of the *Grenzhorizont* to the diagram of Fig. 25 in addition to the *Corylus* curve the curves for

I Melbeck III, ?I (OVERBECK and SCHNEIDER, 1938)
Wittmoor (HALLIK, 1949)

II Holler Moor (OVERBECK and SCHMITZ, 1931)
Worpswede (SCHROEDER, 1930)

III Oldenbrooker Moor II (OVERBECK and SCHMITZ, 1931)
Dannenberg (OVERBECK and SCHMITZ, 1931)
Tinner Dose (KOCH, 1934*b*)
Vriezenveen, Bruine Haar (FLORSCHÜTZ and WASSINK, 1935)

IV Am Lengener Meer (OVERBECK and SCHMITZ, 1931)
Neudorf (BRINKMANN, 1934)
Mantinge (BROUWER, 1947)
Bolleveen a (WATERBOLK, 1950)

V Weinkaufsmoor (OVERBECK and SCHMITZ ,1931)
Walchumer Moor (KOCH, 1934*a*)
Bunnerveen III (BROUWER, 1947)
Iselersheim (SCHUBERT, 1933)
Huvenhoopmoor (SCHUBERT, 1933)

VI Witteveen-Havelte (WATERBOLK, 1954*b*)
Fresenburgsmoor, "Bei der Höhne" (SCHUBERT, 1933)
Spolsener Moor (OVERBECK and SCHMITZ, 1931)
Hoornder Veen (ESHUIS, 1936)
Vriezenveen, Boerendijk (FLORSCHÜTZ and WASSINK, 1935)
Wolfsbrucher Moor (SCHUBERT, 1933)
Minstedt (SCHUBERT, 1933)
Dannenberg (OVERBECK and SCHNEIDER, 1938)
Bergedorf 1 (SCHROEDER, 1930)

VII Oldenbrooker Moor I (OVERBECK and SCHMITZ, 1931)
An den drei Pütten (OVERBECK and SCHMITZ, 1931)
Kollrunger Moor (WILDVANG, 1934*b*)
Wittmarscher Moor (KOCH, 1934*a*)

VIII Fochteloo (Fig. 7)
Langenmoor Mitte (SCHUBERT, 1933)

IX Roswinkel (Fig. 8)
Wildes Moor (WILDVANG, 1934*b*; KOCH, 1934*a*)
Veerssener Moor (KOCH, 1934*b*)

X Vriezenveen, Paterswal I (FLORSCHÜTZ and WASSINK, 1935)
Seehausen (SCHROEDER, 1930)

XI Bargercompascuum (Fig. 11)

XII Mulsemer Hohenmoor (SCHUBERT, 1933)
Emmererfscheidenveen D (Fig. 20)

XIII Fresenburgsmoor, "Östliches Profil" (SCHUBERT, 1933)

XIV Emmererfscheidenveen I (Fig. 4)

Fagus and *Carpinus* are used. It has already been pointed out that in the diagrams from the northern Netherlands and north-west Germany the curves for both trees bear a good resemblance. Although it has been taken into account that because of the reasons mentioned above it is not always possible to transfer the position of the *Grenzhorizont* very accurately, the distance between the successive positions of this contact surface is rather small. One may ask whether there is sense in distinguishing positions which lie so near to each other. Although it is occasionally indeed difficult to choose between two successive positions of the *Grenzhorizont*, in general this is quite well possible. It is clear that *e.g.* the position of the *Grenz* in the "Bunnerveen" III diagram corresponds with the first increase of *Carpinus*, whereas the *Grenzhorizont* in the diagram from Mantinge lies above this increase.

So the result of this comparison of the position of the *Grenz* in the various diagrams is that in the raised bogs from north-west Germany and the Netherlands the transition from humified to fresh *Sphagnum* peat could take place during a long period. Consequently this transition not only occurred at about 500 B.C. or at a limited number of times. It is true that a certain concentration in the occurrence of the *Grenzhorizont* can be seen at position VI. It is also striking that an early *Grenzhorizont* is most often found in the northern Netherlands. This does not mean, however, that we should simply speak of a shifting of the position of the *Grenzhorizont* from west to east. It is in this connection that attention must be drawn to the early position of this contact surface in one of the profiles from the "Fresenburgsmoor", whilst also in the "Mulsemer Hohenmoor" the *Grenzhorizont* was formed at an early time. It is not unlikely that in the profile from the "Berumfehner Moor", where a marked "*Vorlaufstorf*" is present (Wildvang, 1934*a*), the contact surface also falls early. It is not possible, however, to compare this diagram adequately with that of Fig. 25 in order to transfer the position of the *Grenz*. In contrast with the early *Grenzhorizont* in various profiles from large raised bogs the transition from humified to fresh *Sphagnum* peat is late in the small raised bogs from the northern Netherlands.

The *Grenzhorizont* in various Danish peat profiles cannot be entirely synchronous either, although the fluctuations seem to be less great than in the northern Netherlands and north-west Germany. When we compare *e.g.* the position of the *Grenzhorizont* (RY III) in the diagram from Skallesøgaard I with that from Fly (Jonassen, 1950), it is clear that in the first case the contact surface lies at 25 cm below the beginning of the continuous *Fagus* curve, whilst in the other diagram this contact surface lies above the beginning of the continuous *Fagus* curve.

VII. PEAT INVESTIGATIONS IN THE NORTHERN PART OF THE PROVINCE OF FRIESLAND

Up to now relatively few peat profiles from the Frisian coastal region have been subjected to pollen analysis. Dijkstra (not pub-

lished), VAN ANDEL (1949) and VAN DONSELAAR and JONKER (1952) examined the so-called lower peat deposits from north-western Friesland. The results of these investigations agree with those from the western Netherlands (FLORSCHÜTZ, 1944), viz. that the post-glacial transgression reached the present coastal region in the first part of the Atlantic time. Not until much later were the peat profiles near Oud-Hof, Doniaga and Parrega analysed by FLORSCHÜTZ (1941*b*) flooded. The upper part of the peat profile near Oud-Hof consisted of fresh *Sphagnum* peat of the *Cymbifolia* section, from which FLORSCHÜTZ concluded that here also in the Subatlantic time peat formation took place. FLORSCHÜTZ supposed that during the transgression, which deposited the clay layer on the peat, the *Cymbifolia* peat near Doniaga and Parrega was uplifted and carried away. VROMAN (1952) was of opinion that the upper part of the Makkumerwaard profile also had been washed away. He thought it not unlikely that in this area the Younger *Sphagnum* peat would have been eroded in the 13th or 14th century A.D., during the formation of the Zuiderzee.

The peat profiles from Lichtaard, Jislum and Klaarkamp which will be discussed in this chapter, are situated in the area west of Dokkum. In this area a mostly undisturbed peat layer is present below a clay deposit 0.50–1 m thick. The peat layer rests on a diluvial sandy subsoil, which shows an emergence near Bornwird. More to the east, in the area north-north-west of Dokkum, no undisturbed peat layer is found below the marine clay. In that area the sea attacked the peat deposits, and large lumps of peat are met with in the clay deposit. According to VAN GIFFEN (1921) the dwelling mound of Aalsum, north of Dokkum, rests on marine clay which contains large lumps of washed-away peat.

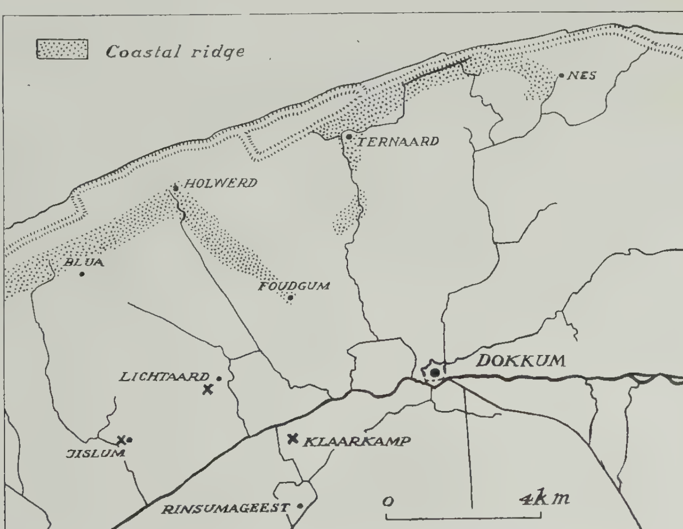

Fig. 26. Map of the coastal region of north-eastern Friesland. The coastal ridge is drawn according to WARTENA (1946).

An explanation of this difference in erosion of the peat landscape can be found in WARTENA's publication (1946). It appears that the coastal ridge running from Blija to Holwerd is broken off near Holwerd, and that this ridge again can be followed from Ternaard up to Nes (Fig. 26). This originally uninterrupted coastal ridge was washed away between Holwerd and Ternaard. The sandy material was re-deposited between Holwerd and Foudgum where at present a sand ridge is found. The ridge between Holwerd and Foudgum protected more or less the peat landscape west and south-west of this ridge against the eroding action of the sea. While in this way practically all peat in the area north-north-west of Dokkum had been taken by the sea, in general the peat deposits west of Dokkum were only covered by a clay deposit. On this clay deposit various dwelling mounds were built whose basal layer generally can be dated at about 100 A.D. (BOELES, 1951, Fig. 32 and Appendix IV).

The peat profiles in the area west of Dokkum are very suitable for a pollen analytical dating of this transgression, as it may expected that here in many cases the complete peat deposit is still present. On some spots, where by means of a boring the presence of peat below the clay could be established, a hole was dug. In this way it was possible to examine whether also the upper part of the peat profile was undisturbed. On account of the high ground water level in this area in most cases it was not possible to reach the diluvial subsoil, so that the lower part of the peat profile had to be sampled with an auger. Finally three peat profiles, namely those from Lichtaard, Jislum and Klaarkamp, which for various reasons were most suitable, were analysed (Figs. 27, 28, 29).

At the sites mentioned above the profile was as follows

Lichtaard	0– 95	cm	undisturbed clay
	95–137	,,	highly humified *Sphagnum* peat with many remains of *Calluna*
	137–146	,,	alternating thin clay and peat layers
	146–153	,,	forest peat
	153–	,,	sand

Jislum	0–100	cm	undisturbed clay
	100–108	,,	disturbed peat
	108–145	,,	highly humified *Sphagnum* peat with many remains of *Calluna*
	145–152	,,	clay layer
	152–157	,,	peat
	157–160	,,	clay layer
	160–170	,,	highly humified fen peat
	170–	,,	sand

Klaarkamp	0– 50	cm	disturbed clay with pieces of cloister bricks
	50– 55	,,	disturbed peat
	55– 83	,,	highly humified *Sphagnum* peat with remains of *Calluna*
	83–130	,,	alternating clay and peat layers
	130–180	,,	forest peat
	180–	,,	sand

Attention has to be drawn to the narrow clay bands occurring in the peat deposits. Similar thin clay layers were often considered as the effect of minor transgressions, on account of which the bog surface would have been flooded only for a short time. After the lowering of the sea level peat formation would have continued. However, a whole series of alternating thin peat and clay layers is often found, while, moreover, the boundaries between clay and peat are very sharp. If after the deposition of a narrow clay layer peat formation again took place, it may be expected that the bog plants were rooting in that clay layer, on account of which there cannot be a sharp contact surface between the clay and the overlying peat. Consequently the narrow clay layers cannot represent interruptions in the peat formation in consequence of transgressions of short duration. The clay bands, however, must have been formed much later, during the transgression which deposited the clay on top of the peat. During storm tides parts of the peat will have been split horizontally and uplifted by the sea water which will have entered the peat landscape through a system of gullies. This uplifting of peat during extremely high tides can still be observed in the "Sehestedter Aussendeichsmoor" near the Jadebusen (*cf.* KÜNNEMANN, 1941, Fig. 1). After the flood the uplifted part of the peat sinks more or less into its original position, but in the meantime a narrow clay layer had been deposited between both peat layers. SCHÜTTE (1927) was of opinion that the peat would always be split at the transition from fen or forest peat to *Sphagnum* peat. BRINKMANN (1934), on the other hand, stated that he never found a clay band at that transition. Although it is true that in the Lichtaard profile some clay bands are present at the transition from forest peat to *Sphagnum* peat, in other—partly unpublished—profiles from this region also in the *Sphagnum* peat narrow clay bands were observed.

It is very likely that the narrow clay bands which occur in the peat profiles from the Princehof (central Friesland), and which would correspond with both Atlantic transgressions established by MULLER and VAN RAADSHOVEN (1947) in the Noordoostpolder (VAN ZEIST, 1950), have no relation with these transgressions, but that they have been much later deposited between the peat. This is very clear for the profile from the Makkumerwaard (VROMAN, 1952). In this profile there is a sandy clay layer between *Eriophorum* peat. It is not probable that after a transgression, which deposited a brackish sandy clay layer, peat formation would have started again with oligotrophic *Eriophorum* peat. TUINSTRA (1951) records that in the north-western part of the province of Noord-Brabant in the vicinity of the original gullies in the Younger *Sphagnum* peat sometimes a narrow clay band occurs which shows the same composition as the clay on top of the peat. TUINSTRA concludes that the clay band must be the effect of a slight transgression phase which would have deposited a narrow clay layer only in the vicinity of the gullies, while at some distance from the gullies peat formation would have continued without interruption. It is more likely, however, that in the vicinity of the gullies the peat

was horizontally split and uplifted during the high tides which deposited the clay on top of the peat.

The beginning of the peat formation in the Lichtaard profile cannot be determined exactly, as the lower part consisted of forest peat, so that the pollen content has been greatly influenced by the local production of pollen. Although the lower spectra of the Jislum profile are more reliable in this respect, it is difficult to give an exact determination of the beginning of the peat formation. In consideration of the *Fagus* percentage peat formation will have started here at the end of the Atlantic time or at the beginning of the Subboreal time.

For a dating of the transgression which deposited the marine clay on top of the peat, the upper part of the diagrams is of importance. It is seen immediately that these diagrams differ somewhat from those discussed in the chapters III and IV. In the Lichtaard diagram the *Corylus* percentage between a depth of 118.5 and 128.5 cm is higher than that of *Alnus*, whilst the *Fagus* percentage—with the exception of the spectrum at a depth of 126 cm—is fairly low below a depth of 118.5 cm (about 1 %). Above 118.5 cm *Corylus* decreases and above 111 cm the *Corylus* values remain below those of *Alnus*. At the same time *Fagus* increases, and reaches an average value of 2.5 %. At the bottom of the Klaarkamp diagram the beginning of the fall of *Corylus* and the rise of *Fagus* can just be seen. The part between 73.5 and 78.5 cm corresponds with the part between 112 and 117 cm in the diagram from Lichtaard. The Jislum diagram is not so easily comparable with the diagram from Lichtaard. The behaviour of *Corylus* is somewhat irregular, whilst in general *Fagus* reaches less high values. The level from where *Corylus* decreases and the *Fagus* curve shows an increase corresponds with a depth of 136.5 cm, whilst the part above 124 cm can be compared with that part of the Lichtaard diagram which lies above 111 cm. A close comparison of the Jislum diagram with both other diagrams remains difficult, however. This is somewhat remarkable as there is no great distance between the various profiles (about 3.5 km).

The high *Myrica* percentages in the Jislum diagram are conspicuous, whilst the upper spectrum of the Lichtaard diagram equally shows a high *Myrica* percentage. It appears that not unfrequently *Myrica* must have been rather abundant on the bogs of the coastal region. Wildvang (1934*b*) reports the occurrence of many leaves and pollen grains of *Myrica* in the upper part of the peat profile from Emden-Wolthusen which is covered by a clay deposit. The peat profiles from Hekelingen in the coastal region of the western Netherlands appear to contain large amounts of *Myrica* pollen (Florschütz, 1953). Zwillenberg and Hendriks (1954) report the occurrence of *Myrica* pollen in the clay-covered peat deposits from Waterland (province of Noord-Holland) not far from the coast either.

The regular occurrence of pollen of *Plantago* and *Cerealia* points to human habitation on the higher sandy soils in this area in Neolithic time and later. The values for *Chenopodiaceae* and *Artemisia*—especially in the diagrams from Lichtaard and Jislum—are higher than those in

the diagrams from regions at a greater distance from the coast, and will undoubtedly be due to the halophytic vegetation of the coastal region. In this respect the regular occurrence of pollen grains of *Plantago maritima* in the upper part of the Lichtaard diagram must be mentioned. Pollen of *Cruciferae*—fairly abundant in "*kwelder*" deposits—was not found in the analysed peat profiles. This will be due to the fact that *Cruciferae* are no wind pollinators, and produce a relatively small amount of pollen grains.

In comparing these diagrams with those from Drente for instance, it has to be taken into consideration that the conditions for the supply of tree pollen were not favourable. It appears that the trees which were growing on the higher sandy soils south of Dokkum must have been the chief contributors of the pollen grains coming down in the bogs west of Dokkum. These higher sandy soils are lying south-east of the investigated peat area, while west of this area nowhere suitable habitats for forest vegetation can have been present. Consequently, a pollen rain of any importance could especially take place with south-eastern winds. In this connection it is easily understandable that *Corylus* shows such high percentages, as in the early spring, when *Corylus* flowers, south-eastern winds blow regularly. How far the irregular *Fagus* curve has to be ascribed to the unfavourable position of this peat area in respect of the forest vegetation is difficult to determine. It is, however, remarkable that the *Fagus* curve—just as those for the other trees—is most regular in the Klaarkamp diagram which of the analysed profiles lies nearest to the higher sandy soils.

The most conspicuous phenomenon in the three diagrams is the fall of *Corylus* which is accompanied by an increase of *Fagus*. In contrast with the diagrams from Drente *Fagus* does not reach here a value of 4–5 %, but only an average of 2–3 %. The level from where *Corylus* decreases and the rise of *Fagus* starts, is found in the diagrams from Lichtaard, Jislum and Klaarkamp at a depth of 118.5, 136.5 and 78.5 cm respectively. This level corresponds with the last *Corylus* maximum (C_4) in the diagrams from Drente.

It is not possible to give an accurate pollen analytical dating of the transgression that deposited the clay on top of the peat. It was, however, a fairly long time after the first expansion of *Fagus*—whose beginning can be dated at about 500 B.C.—that peat formation came to an end owing to the deposition of clay. A *terminus ante quem* gives the basal layer of the dwelling mounds from this area which can be dated at about 100 A.D. (see p. 64). On the ground of both data the deposition of clay must have started shortly before the beginning of the era.

By Edelman and collaborators (Edelman, 1953) three phases are distinguished in the so-called Subatlantic transgression, viz. a pre-Roman, a late-Roman to early-Mediaeval and a third phase starting at about 1000 A.D. The first phase of the Subatlantic transgression attacked various parts of the Dutch coastal region. Bennema and Van der Meer (1950) record that shortly before or about the begin-

ning of the era the northern part of Walcheren was flooded by the sea. The pre-Roman ebb and flood channels in the peat landscape of Westland have been investigated by VLAM (1945) and VAN LIERE (1948). DE ROO (1949) could establish pre-Roman inroads on the coast of Kennemerland, whilst DU BURCK (1949) found a pre-Roman attack of the landscape in Geesterambacht. With regard to Friesland it can be mentioned that BAKKER (1954) dated the formation of the tidal flat sand ridge between Dongjum and Berlikum at about 200–100 B.C., which formation would point to a temporary stronger rise of the sea level.

The influence of the late-Roman to early-Mediaeval phase of the Subatlantic transgression could be established in several places along the coast of the provinces of Noord- and Zuid-Holland and Zeeland. This transgression would also have left traces in the province of Friesland. According to VEENENBOS (1949) the old landscape south of Franeker consisted of marine deposits. Through this landscape various channels were running on the bank of which prehistoric man had settled. Later on, these settlements developed into dwelling mounds. This old landscape was covered by a tough clay, poor in lime, the so-called sticky clay. VEENENBOS (1949) places the deposition of this sticky clay in the period from 300 to 800 A.D. According to BAKKER (1954) the tidal flat sand ridge in Barradeel near the old sea dike, parallel to the present coast, was formed at about 300–400 A.D.

The transgression that deposited the clay on the peat landscape west of Dokkum can be assigned to the pre-Roman phase of the Subatlantic transgression.

A comparison of the Oud-Hof diagram (FLORSCHÜTZ, 1941*b*) with the diagrams from Lichtaard, Jislum and Klaarkamp shows that it is not unlikely that also in the south-western part of the province of Friesland the peat landscape must have been flooded during the first phase of the Subatlantic transgression.

The clay area of the province of Groningen has less thoroughly been investigated than many other parts of the Dutch coastal region. As appears from the profiles published by KOOPER (1939) and WIGGERS (1950) often two peat layers are met with in the subsoil of the clay area of the province of Groningen. The lower peat layer rests on diluvial sand. In connection with the results of the investigation in the western Netherlands it is obvious to suppose that this peat layer can be compared with the so-called lower peat deposits which were flooded at the beginning of the Atlantic time. Up to now no samples from this peat layer from Groningen were analysed. VERMEER-LOUMAN (1934) only analysed a partly humous clay from a depth of about — 16.80–17.50 m N.A.P. (Amsterdam Ordnance Datum) near Uithuizen. The high *Pinus* percentage in the humous clay is no evidence of a Boreal age, as in general the *Pinus* percentages in clay deposits are high.

On top of the Atlantic clay a peat deposit has been formed which again was covered by a clay layer. In the upper clay deposit two

phases separated by a distinct humous horizon can be located. The dwelling mounds rest on that old surface. This would suggest that the flooding of the peat landscape in Groningen must have taken place before the beginning of the era (WIGGERS, 1950).

Dr. U. TUINSTRA at Warffum placed a number of peat profiles covered by marine clay at our disposal which would make possible a pollen analytical dating of one or more transgressions. Unfortunately the pollen analytical examination did not lead to a positive result.

For the adjacent Ostfriesland (north-western Germany) HAARNAGEL (1950) mentions that there the time between about 700 and 300 B.C. was a transgression period.

VIII. DISCUSSION

THE PODZOL PROFILE

In consequence of the interference of Neolithic man with the natural vegetation the heather must locally have played an important part already in Neolithic time. The rather high *Calluna* percentages in a number of Neolithic spectra, *e.g.* Oudemolen tumulus 12, Vries tumulus III, Emmen *hunebed* D XLI, Noordse Veld tumulus 37 (WATERBOLK, 1954*b*) and Oudemolen tumulus 13 (Table VII) point to a local expansion of the heather. In spite of these fairly high *Calluna* percentages a podzol profile never occurs below a Neolithic burial monument (VAN GIFFEN, 1941*b*). Below Bronze Age tumuli, on the other hand,—at least on the higher sandy soils—a podzol profile is always present, even if sometimes the *Calluna* percentages are rather low, *e.g.* "Eupen Barchien" (WATERBOLK, 1954*b*), Hijken tumuli 9 and 10 (Table II). The stone cist tumulus near Diever and the barrow of light-coloured sods lying near this tumulus showed a beginning of podzolization. In the subsoil of these tumuli a leached layer was already present, but no hard pan yet.

WATERBOLK (1954*b*) has already pointed out that the development of a podzol profile below a heather vegetation must have been effected by an increase of precipitation. This increase of precipitation likewise offered conditions favourable to a further expansion of the heather. On account of the exhaustive cultivation – as was practised in the Netherlands at least until the end of the Bronze Age—a considerable impoverishment of the upper soil layer took place. At the beginning of the Bronze Age this impoverishment became stronger, since the leaching began to play an important part because of the increased precipitation. In consequence of this strong impoverishment of the upper soil layer the conditions for a regeneration of the forest —which in Neolithic time undoubtedly must have occurred—became very unfavourable, so that the heather, which makes low demands upon the mineral content of the soil, could easily expand after the cultivated area had been abandoned. Moreover, the acid humous layer of the *Calluna* vegetation intensifies the leaching of the soil, as on account of the low pH the iron and aluminium compounds dissolve, whilst

a cemented hard pan prevents the regeneration of the forest as the roots cannot penetrate through that layer.

The development of a podzol profile in the Bronze Age thus points to an increased precipitation which effected a strong leaching of the soil. Another indication of this increased rainfall can be observed in the various profiles from the raised bog near Emmererfscheidenveen. In this raised bog fresh *Sphagnum cuspidatum* peat layers occur from the transition between Neolithic time and Bronze Age (*cf.* Emmererfscheidenveen A and B—Figs. 17 and 18—in which this *Sphagnum cuspidatum* layer starts just below and above the first, small increase in the *Fagus* curve respectively). The formation of this type of peat must be the effect of an increase in rainfall, on account of which small pools were formed on the surface of the bog. In these pools the hydrophilous *Sphagnum cuspidatum* could develop. The fact that this *Sphagnum cuspidatum* layer is highly fissile suggests that these pools dried up in the summer.

Although human activity should establish the possibility for a development of the heather vegetation by clearing the forest, it was a climatological phenomenon, namely an increase in precipitation, which was the determining factor for the expansion of the heather.

Although the difference in soil profile below Neolithic and Bronze Age barrows has led to the conclusion that the formation of a podzol profile did not take place until the beginning of the Bronze Age, some attention has to be paid to those pollen analytical examinations which would point to an earlier development of the podzol profile. The conception at which Beijerinck (1933, 1934) and Benrath and Jonas (1937) arrived on the ground of pollen analytical investigations of the concerning layers, viz. that the hard pan would be an arctic formation, and that the leached layer would have been formed during a more generous climate, cannot be correct, since well developed podzol profiles on the surface of barrows are known. Moreover, Beijerinck (1941, 1943) has modified his original view, and nowadays he considers the hard pan and leached layer as formations of winter and summer climate respectively. The result of the pollen analytical investigation of leached layers by Florschütz (1941*a*) can also be left out of consideration, as it appears clearly from the investigations of Selle (1940) that the pollen spectra of the leached layer of a podzol profile are not reliable, and that consequently those spectra cannot yield data about the time of development of the podzol profile.

It cannot be denied, however, that in a number of cases peat formation above a podzol profile started before the beginning of the Bronze Age. From this it follows that the podzol profile in question must have developed at an earlier time. Schroeder (1934) described a "Boreal" podzol profile from the Wieringermeer. The peat formation on top of this profile started at the beginning of the Atlantic time. The Ericaceous percentages in the lower sandy part are very high. The profile L from the Wieringermeer (Vermeer-Louman, 1934) also points to the presence of a podzol profile below Atlantic peat. Near Terhorne (south-west Friesland) Bodlaender (1950)

found a well developed podzol profile which was overgrown by peat at about the Boreal/Atlantic transition. In north-west Brabant the presence of a podzol below peat was also established (TUINSTRA, 1951).

It is striking that similar "old" podzol profiles always occur below peat, whereas they have never been met with on the higher sandy soils. In the so-called double podzol profiles of Havelte (WATERBOLK, 1954*b*) and Wijster (VAN ZEIST, 1954) there are no indications of a pre-Bronze Age development of the lower podzol. It is in this connection that mention should be made of the stratigraphical examination of the raised bog from south-east Drente by VISSCHER (1931). This author reports that in general a leached layer and a hard pan occur below the peat. The thickness of the leached layer would range from 5–30 cm, that of the hard pan from 10–50 cm. On the higher parts of the undulating subsoil the hard pan would be weakly developed, rather soft and light-coloured. On the lower parts this layer would be more cemented and dark-coloured.

On account of these investigations it must indeed be concluded that at low lying sites, where peat formation has taken place already before the beginning of the Bronze Age, a podzol profile could develop. This would be in conflict with the results of the barrow investigations. The question arises whether the podzol profile below a bog can be compared with that on the higher sandy soils. For a typical heather podzol develops at sites where the ground water table is not too high. It may be expected, however, that just at sites where peat formation could take place, the ground water will have been high. It is a well-known fact that in water-logged soils gleization takes place (ground water profiles). In that case a leached layer may occur below the humous to peaty topsoil. In sandy soils besides the leached layer a B-(iron accumulation) layer is often met with (VEENENBOS, 1953). JOFFE (1949, p. 432) records the occurrence of podzol profiles with a clear, bleached A_2- and a, not unfrequently cemented, coffee-brown B-horizon below peat and at other sites with a high ground water table. JOFFE considers these profiles as a hydromorphic sub-type of the podzol profile. For this reason it is very likely that the podzol profile which also in the Netherlands is found below peat, represents such a ground water profile.

THE PROBLEM OF THE *Grenzhorizont*

In Chapter VI the results have been discussed of the investigation into the pollen analytical position of the *Grenzhorizont* which constitutes the transition from highly humified to fresh *Sphagnum* peat. As already has been stated on p. 51 by VAN GIFFEN (1947, 1950) and WATERBOLK (1950) the beginning of the growth of the Younger *Sphagnum* peat is dated at about 400 A.D. on the ground of an examination of the "Bolleveen" near Zeijen. They arrived at the conclusion that in general the *Grenzhorizont* would not correspond with the RY III, but with the RY II. VAN GIFFEN (1950, 1954*b*) connects the marine transgression after the third century A.D. with the beginning of the formation of fresh *Sphagnum* peat in the small

raised bogs from Drente. According to VAN GIFFEN the formation of the Younger *Sphagnum* peat would be effected by a rise in the ground water table which would be closely bound up with the mentioned transgression. WATERBOLK (1954*b*) also associates this transgression with the beginning of the formation of fresh *Sphagnum* peat, whilst according to BENNEMA (1954) there would in general be a correlation between the occurrence of recurrence surfaces and transgressions. Previously WASSINK (1939) pointed already to a possible connection between the height of the sea level and the peat formation.

It is not likely, however, that a rise in the sea level of perhaps 1–1.50 m will have effected a considerable rise in the ground water in regions at a fairly great distance from the coast. Moreover, the investigations of EDELMAN and collaborators have demonstrated that there must also have been, among others, a pre-Roman transgression (*cf.*pp. 67–68). This transgression should, according to the hypothesis of VAN GIFFEN and WATERBOLK, also have to find expression in the stratigraphy of the raised bogs. However, VAN GIFFEN and WATERBOLK assume a standstill in the peat formation in the small raised bogs during the pre-Roman and Roman Iron Age, whilst during that time the peat formation in the large raised bogs would have been of slight importance. So there would be no correlation between the pre-Roman transgression and the peat formation. Besides, in the large raised bogs the formation of fresh *Sphagnum* peat appears to have started at times which cannot be linked up with a transgression.

It is more likely that the transition from highly humified to fresh *Sphagnum* peat has to be considered as the effect of climatological factors. In the raised bog from Emmererfscheidenveen the formation of fresh *Sphagnum* peat often started with a *Sphagnum cuspidatum* layer. As has already been remarked this layer must have been effected by a rather heavy precipitation which caused the formation of small pools on the bog surface. The fact that in some cases on top of the *Sphagnum cuspidatum* layer there is again a layer of humified *Sphagnum* peat suggests that in general that time (Bronze Age) was not yet very favourable to the formation of fresh *Sphagnum* peat, probably on account of still too high a temperature and too low a humidity.

In view of the fact that in the large raised bog from south-east Drente the formation of fresh *Sphagnum imbricatum* and *papillosum* peat started at about the beginning of the Iron Age, it seems likely that at that time the conditions for the formation of fresh *Sphagnum* peat became more favourable in this region. Particularly the expansion of *Sphagnum imbricatum* suggests that the moisture of the peat must have been very high. From SCHWICKERATH's (1944) examination of the vegetation of the "Hohe Venn" it is clear that *Sphagnum imbricatum* only grows in the wettest places of the raised bog. At the beginning of the Iron Age the general humidity must have increased in such a way (lower temperature, increased precipitation?) that in the large raised bogs –with the exception of the border zones—the surface of the bog became sufficiently moist in order to establish conditions

favourable to the growth of *Sphagnum imbricatum*. At the same time the first expansion of *Fagus* took place. In Denmark MIKKELSEN (1949, 1952) ascribes the expansion of *Fagus* by jumps to three moist phases in the Subatlantic time. Consequently, there would be a correlation between the expansion of *Fagus* and the humidity.

This increase in humidity at the beginning of the Iron Age effected the formation of fresh *Sphagnum* peat only in large raised bogs. For the present the formation of fresh *Sphagnum* peat did not yet take place in the small raised bogs from Drente, whilst in the same way in a great number of profiles from north-west Germany the transition from humified to fresh *Sphagnum* peat occurred rather late.

It is certain that besides climatological factors the local conditions had great influence on the transition from Older to Younger *Sphagnum* peat. For the investigation into the pollen analytical position of the *Grenzhorizont* in the raised bog from south-east Drente has clearly demonstrated that even in a single raised bog this transition cannot have been a synchronous phenomenon, but that local factors must have played an important part. The same phenomenon appears to be present in various other raised bogs. In this connection it is interesting that just in the border zone of the raised bogs this transition did not take place until later times. This agrees with the fact that in the small raised bogs from Drente the *Grenzhorizont* is likewise late. Just as in the border zone of the large raised bogs the small raised bogs are relatively well drained, so that it lasted much longer before the conditions for the formation of fresh *Sphagnum* peat became favourable here. On account of the increased humidity which effected a lower evaporation, the ground water table must have risen. Consequently, this rise in the ground water considerably impeded the drainage of the small raised bogs, so that here also the conditions for the formation of fresh *Sphagnum* peat became favourable.

In the various small raised bogs from Drente the *Grenzhorizont* also appears not to be a synchronous phenomenon. In Fig. 25 the position of the *Grenz* in three small raised bogs is indicated, viz. the "Witteveen" near Havelte, the "Bolleveen" near Zeijen and the "Bunnerveen". Although there is not much difference in time between the formation of the *Grenzhorizont* in these bogs, it easily runs to some hundreds of years. This again points to the fact that besides climatological factors, the local conditions must have been of much importance to the formation of fresh *Sphagnum* peat.

It seems likely that at first edaphic factors were prevailing, which prevented the formation of fresh *Sphagnum* peat, and that only in favourable places in the raised bogs from western Europe the formation of fresh *Sphagnum* peat started as soon as the climatological factors allowed this. Not until much later, during the first four or five centuries A.D., the influence of unfavourable edaphic factors greatly declined. The diagram of Fig. 25 illustrates a concentration of *Grenzhorizonts* in that part of the diagram which corresponds with the first five centuries A.D. When we compare the peat formation over large areas it should also be borne in mind that in one region

the influence of a given climatic factor will be much greater than in another region (*cf.* OVERBECK, 1952).

WEBER's conception that the Older *Sphagnum* peat would have attained its present state of humification during a period of standstill in the peat formation could easily explain the sudden transition from highly humified to fresh *Sphagnum* peat. The present view that—at least in the large raised bogs—there has not been a standstill in the peat formation, renders an explanation of the sudden transition more difficult, since the climatic changes which are responsible for this transition always elapse rather gradually. Recently NIETSCH (1953) commented upon this question. Although OVERBECK (1947) and OVERBECK and SCHNEIDER (1940) could demonstrate that a certain decrease in the degree of humification often takes place already at some depth below the marked contact surface, yet the humification curve shows a sharp decline at the transition from Older to Younger *Sphagnum* peat.

THE CORRELATION BETWEEN THE RESULTS OF POLLEN ANALYSIS OF SAMPLES FROM BOGS AND FROM BURIAL MONUMENTS

Concerning the correlation between the results of the pollen analytical investigation of sand samples and those of peat samples the following can be remarked.

Although *Fagus* occurs regularly already in the Neolithic part of the pollen diagrams from the large raised bogs as well as from the small ones, pollen of this tree is in general not met with in the spectra of the Neolithic burial monuments in the northern Netherlands. The rather high *Fagus* percentage in the sample from the *hunebed* near Wapse is an exception. It is very likely that—apart from some exceptional cases—*Fagus* did not yet grow here during the Late Stone Age.

The examination of the pollen analytical position of archaeological objects discovered in the peat has demonstrated that the first, slight increase in the *Fagus* curve approximately coincides with the transition from Neolithic time to Bronze Age. The fact that—in contrast with the Neolithic spectra—in all spectra from Bronze Age *Fagus* is present is in accordance with the increase in the *Fagus* curve in the pollen diagrams.

The expansion of *Fagus* at the beginning of the Iron Age is likewise reflected in the barrow spectra from that time which show considerably higher *Fagus* values than the Bronze Age spectra. On account of the local circumstances the *Fagus* values can remain low, but then also —compared with the corresponding Bronze Age spectra—a marked increase can be seen (*cf.* Table V). In general the spectra of sand samples from the Iron Age show a lower *Fagus* percentage than the corresponding spectra in the diagrams from raised bogs.

In agreement with the diagrams from the raised bogs *Carpinus* occurs regularly in the sand samples from the Iron Age. The *Carpinus* values in sand samples are—just as those for *Fagus*—lower than in the corresponding peat samples.

The Neolithic and Bronze Age part of the diagrams cannot be

distinguished by a difference in *Corylus* values. In both periods the curve for this tree shows some fluctuations. The marked decline of *Corylus* from the beginning of the Iron Age is also reflected in the spectra of the sand samples from that time. Especially the spectra of the Iron Age barrows near Wijster (Table V) all show low *Corylus* percentages. The *Corylus* values in the samples from the Anglo-Saxon cemetery near Zweeloo (Table IV) are also low.

The relatively high *Tilia* values are characteristic of many Neolithic spectra. Confining ourselves to the northern Netherlands the highest values found up to now are: *hunebed* Steenbergen 8.5 %, *hunebed* Exloo 6.6 %, *hunebed* Emmen D XLI 6.2 %, tumulus III near Vries 4.7 %, tumulus I Noordse Veld 12 %. The *Tilia* values in Bronze Age samples do not reach such high percentages. In contrast with the pollen diagrams from bogs in which the *Tilia* values from the Bronze Age are only slightly lower than those from the Neolithic time, the *Tilia* values in sand samples from both periods can differ considerably. While in general the *Tilia* values in peat and sand samples from the Bronze Age show considerable agreement, Neolithic sand samples not unfrequently show *Tilia* values which are much higher than in the corresponding peat samples. Although high *Tilia* percentages occur in a number of Neolithic sand samples, the *Tilia* values in other Neolithic sand samples are not much higher than those in the Bronze Age sand samples, *e.g.* Hijken tumuli 1 (period 2) and 8 (period 1), "Galgenberg" near Ruinen (period 1) and Oudemolen tumulus 13 (period 1) which yielded the following *Tilia* values: 1.1, 0.9, 1.9 and 0.8 %. Waterbolk (1954*b*) drew attention to the fact that the *Tilia* percentages in barrows from a given area and from about the same time may differ considerably. These difference could be effected by a local occurrence of *Tilia*, but it seems more likely that there is a correlation between the *Tilia* value and the state of preservation of the pollen grains. For it appears that the Neolithic samples which contain badly preserved pollen, show a high *Tilia* percentage, *e.g.* Hijken tumulus 1 (period 1) and the samples from the *hunebeds* near Steenbergen, Exloo, and Diever, whereas this percentage is low in some Neolithic samples with a fairly good state of preservation, *e.g.* Hijken tumuli 1 (period 2) and 8 (period 1), Oudemolen tumulus 13 (period 1). In addition it is remarkable that in Bronze Age samples with badly preserved pollen *Tilia* shows fairly high values, *e.g.* Hijken light-coloured sod (2.4 %) and old arable (3.4 %) of tumulus 5 and old arable (3.0 %) of tumulus 6, whilst the *Tilia* value in the samples with a good state of preservation from both tumuli is 0.8 %.

In this connection the result of Selle's investigation (1940) is of importance. This author found extremely high *Tilia* values in samples from the leached layer of the podzol profile, whereas in the pollen diagrams from small raised bogs in the vicinity the values for this tree were constantly low. According to Selle these high *Tilia* values in sand samples have to be ascribed to a differential preservation favouring *Tilia*.

In consideration of these experiences and the fact that in Neolithic sand samples with a good state of preservation the *Tilia* values agree well with those in the corresponding peat samples, it is highly probable that the high *Tilia* values in a number of Neolithic spectra have not been effected by a local occurrence of *Tilia*, but by a differential preservation.

In accordance with the expectation the Iron Age sand samples show very low *Tilia* values (about 0.3 %), whilst in the samples from the Anglo-Saxon cemetery near Zweeloo *Tilia* is completely absent.

For the same reason as for *Tilia* it is very probable that a bad state of preservation has favoured the pollen of *Plantago lanceolata*. Through the presence of the characteristic pores even badly preserved pollen grains of this species can be easily recognized. The high values for *Sphagnum* and *Dryopteris* in Neolithic samples with badly preserved pollen grains will—at least partly—be due to the high resistance of the spore wall.

In general it can thus be stated that the results of the pollen analytical examination of the raised bogs are in good agreement with those of samples from burial monuments.

REFERENCES

Aario, L. 1940. Waldgrenzen und subrezenten Pollenspektren in Petsamo Lappland. Ann. Acad. Scient. Fenn. A 54, No. 8.

Andel, T. van. 1949. Pollenanalytische datering van een holocene transgressie in Noord-West Friesland. Geologie en Mijnbouw N.S. 11 : 171–3.

Bakker, J. P. 1954. Relative Sea-Level Changes in Northwest Friesland (Netherlands) since pre-historic Times. Geologie en Mijnbouw N.S. 16 : 232–46.

Bennema, J. 1954. Bodem-en zeespiegelbewegingen in het Nederlandse kustgebied. Thesis Wageningen. 85 pp.

Bennema, J. en K. van der Meer. 1950. De genese van Walcheren. Tijdschr. Kon. Ned. Aardr. Gen. 67 : 399–408.

Benrath, W. und F. Jonas. 1937. Zur Entstehung der Ortstein-Bleichsandschichten an der Ostseeküste. Planta 26 : 614–30.

Bertsch, F. in A. Cassau. 1935. Ein Feuersteindolch mit Holzgriff und Lederscheide aus Wiepenkathen, Kreis Stade. Mannus 27 : 199–209.

Bertsch, K. 1942. Lehrbuch der Pollenanalyse. Stuttgart. 195 pp.

Beijerinck, W. 1933. Die mikropaläontologische Untersuchung äolischer Sedimente und ihre Bedeutung für die Florengeschichte und die Quartairstratigraphie. Proc. Kon. Akademie van Wetenschappen te Amsterdam 36 : 107–15.

Beijerinck, W. 1934. Humusortstein und Bleichsand als Bildungen entgegengesetzter Klimate. Proc. Kon. Akademie van Wetenschappen te Amsterdam 37 : 93–8.

Beijerinck, W. 1941. Enkele beschouwingen over de geographische verspreiding van het z.g. podsol-profiel en den samenhang der verschillende lagen in dat profiel. Besprekingen over het Heidepodsolprofiel, gehouden op de Bijeenkomst der Sectie Nederland van de Intern. Bodemkundige Vereeniging op 18 en 19 April 1941 : 24–30.

Beijerinck, W. 1943. Bodem en levensdek in Drenthe. In : Drente, een handboek voor het kennen van het Drentsche leven in voorbije eeuwen, onder redactie van J. Poortman. Eerste deel. Meppel. 123–61.

Blytt, A. 1876. Essay on the immigration of the Norwegian flora during alternating rainy and dry periods. Christiania. 89 pp.

Bodlaender, K. B. A. 1950. Palaeobotanical Investigation in the Vicinity of the Sneeker Meer (Province of Friesland, The Netherlands). Rec. d. trav. bot. néerl. 33 : 313–33.

Boeles, P. C. J. A. 1951. Friesland tot de elfde eeuw. 2e druk, 's-Gravenhage. 598 pp.

Boone, W. J. de. 1954. De Franken, van hun eerste optreden tot de dood van Childerik. Thesis Groningen. 225 pp.

Brinkmann, P. 1934. Zur Geschichte der Moore, Marschen und Wälder Nordwestdeutschlands. III. Das Gebiet der Jade. Bot. Jahrb. 66 : 371–445.

Brouwer, A. 1947. Pollenanalytisch onderzoek van overstoven Drentse veentjes. Tijdschr. Kon. Ned. Aardr. Gen. 64 : 1–12.

Burck, P. du. 1949. Bodemkartering van Geesterambacht. Boor en Spade 3 : 152–67.

Dobben, W. H. van. 1932. Resultate von Untersuchungen an einigen niederländischen Mooren. C. Valthermond. Rec. d. trav. bot. néerl. 29 : 12–5.

Donselaar, J. van and F. P. Jonker. 1952. A Palynological Investigation of the Lower Peat in the Province of Friesland, The Netherlands. Acta Bot. Neerl. 1 : 259–67.

Edelman, C. H. 1953. De sub-atlantische transgressie langs de Nederlandse kust. Geologie en Mijnbouw N.S. 15 : 351–64.

Erdtman, G. 1943. An Introduction to Pollen Analysis. A new Series of Plant Science Books, Vol. XII. Waltham (Mass.). 239 pp.

Erdtman, G. and H. 1933. The improvement of pollen-analysis technique. Svensk Bot. Tidskr. 27 : 347–57.

Eshuis, H. J. 1936. Untersuchungen an niederländischen Mooren. K. Westerwolde. Rec. d. trav. bot. néerl. 33 : 688–704.

Eshuis, H. J. 1946. Palynologisch en stratigraphisch onderzoek van de Peelvenen. Thesis Utrecht. 144 pp.

Faegri, K. and J. Iversen. 1950. Textbook of Modern Pollen Analysis. Copenhagen. 168 pp.

Firbas, F. 1949. Spät- und nacheiszeitliche Waldgeschichte Mitteleuropas nördlich der Alpen. Band I, Allgemeine Waldgeschichte. Jena. 480 pp.

Florschütz, F. 1941*a*. Resultaten van microbotanisch onderzoek van het complex loodzand-oerzand en van daaronder en daarboven gelegen afzettingen. Besprekingen over het Heidepodsolprofiel, gehouden op de Bijeenkomst der Sectie Nederland van de Intern. Bodemkundige Vereeniging op 18 en 19 April 1941 : 36–56.

Florschütz, F. 1941*b*. Palaeobotanische bijdrage tot de oplossing van het schalterprobleem der Friesche weiden. Tijdschr. Ned. Heidemij 53 : 419–26.

Florschütz, F. 1944. Laagterras en "veen op grootere diepte" onder Velzen. Tijdschr. Kon. Ned. Aardr. Gen. 61 : 25–33.

Florschütz, F. 1953. Palaeobotanisch onderzoek in verband met de opgravingen in de polder Vriesland bij Hekelingen. Berichten Rijksd. Oudheidk. Bodemond. 4, no. 2 : 19–24.

Florschütz, F. und E. C. Wassink. 1935. Untersuchungen an niederländischen Mooren. H. Vriezenveen; J. Roswinkel. Rec. d. trav. bot. néerl. 32 : 438–52.

Florschütz, F. und E. C. Wassink. 1941. Untersuchungen an niederländischen Mooren. L. Ergebnisse der Untersuchung einiger kleinen Moore im drenther Heidegebiet. Rec. d. trav. bot. néerl. 38 : 1–12.

Giffen, A. E. van. 1918. Begin van een onderzoek van "de zoogenaamde voormalige Romeinsche legerplaats" en aangelegen grafheuvelveld te Zeijen. Nieuwe Drentsche Volksalmanak 36 : 135–75.

Giffen, A. E. van. 1920. Grafheuvels uit den vroegen bronstijd bij Zeijen. (Voorloopig bericht.) Nieuwe Drentsche Volksalmanak 38 : 122–46.

Giffen, A. E. van. 1921. Bijdrage tot de kennis van enkele geologisch-archaeologische verkenmerken in verband met het vraagstuk der bodemdaling in historischen tijd. Verslagen der Geologische Sectie van het Geologisch-Mijnbouwkundig Genootschap voor Nederland en Koloniën II (1915–1919) : 159–220.

Giffen, A. E. van. 1925. De ligging der archaeologica in het hoogveen. Hand. XX. Nat. en Geneesk. Congres : 265–8.

Giffen, A. E. van. 1925–1927. De hunebedden in Nederland. Tekst deel I en II. Atlas deel I en II. Utrecht.

GIFFEN, A. E. VAN. 1930. Die Bauart der Einzelgräber. Beitrag zur Kenntnis der älteren individuellen Grabhügelstrukturen in den Niederlanden. Mannus-Bibliothek 44 und 45. Leipzig.

GIFFEN, A. E. VAN. 1941*a*. Oudheidkundige aanteekeningen over Drentsche vondsten (VIII). Nieuwe Drentsche Volksalmanak 59 : 101–41.

GIFFEN, A. E. VAN. 1941*b*. De tijd van vorming van de heidepodsolprofielen aan de hand van archaeologische waarnemingen. Besprekingen over het Heide-podsolprofiel, gehouden op de Bijeenkomst der Sectie Nederland van de Intern. Bodemkundige Vereeniging op 18 en 19 April 1941: 12–23.

GIFFEN, A. E. VAN. 1943. Opgravingen in Drente. In : Drente, een handboek voor het kennen van het Drentsche leven in voorbije eeuwen, onder redactie van J. Poortman. Eerste deel, 2e druk. Meppel. 393–568.

GIFFEN, A. E. VAN. 1949. Oudheidkundige aantekeningen over Drentse vondsten (XVI). Het "Noordse Veld" bij Zeijen, gem. Vries. Opgravingen in 1944. Nieuwe Drentsche Volksalmanak 67 : 93–125.

GIFFEN, A. E. VAN. 1950. Oudheidkundige aantekeningen over Drentse vondsten (XVII). De nederzettingsoverblijfselen in het Bolleveen en de versterking, de zgn. "Legerplaats", aan het Witteveen op het Noordse Veld, beide bij Zeijen, gem. Vries. Nieuwe Drentsche Volksalmanak 68 : 89–99.

GIFFEN, A. E. VAN. 1951. Oudheidkundige aantekeningen over Drentse vondsten (XVIII). De Havelterberg en omgeving bij Havelte, gem. Havelte. Nieuwe Drentsche Volksalmanak 69 : 97–157.

GIFFEN, A. E. VAN. 1952. Oudheidkundige aantekeningen over Drentse vondsten (XIX). Het Bolleveen bij Zeijen, gem. Vries. Naschrift. Nieuwe Drentsche Volksalmanak 70 : 89–108.

GIFFEN, A. E. VAN. 1954*a*. Oudheidkundige aantekeningen over Drentse vondsten (XX). Een grafheuvelonderzoek op de Emelange bij Wijster, gem. Beilen. Nieuwe Drentsche Volksalmanak 72 : 159–80.

GIFFEN, A. E. VAN. 1954*b*. Archäologische Bemerkungen zur Frage der Niveau-veränderungen im niederländischen Küstengebiet. Geologie en Mijnbouw N.S. 16 : 226–31.

GODWIN, H. 1943. Coastal peat beds of the British Isles and North Sea. Journ. of Ecology 31 : 199–247.

GODWIN, H. 1950. The Late-Glacial Vegetation of Great Britain. Proceedings of the Seventh International Botanical Congress, Stockholm : 633–4.

GRANLUND, E. 1932. De svenska högmossernas geologi. Sveriges geol. undersök. C 373 Arsbok 26, I : 1–193.

GROSS, H. 1930. Das Problem der nacheiszeitlichen Klima- und Florenentwicklung in Nord- und Mitteleuropa. Beih. Bot. Centralblatt 48: 1–110.

HAARNAGEL, W. 1950. Das Alluvium an der deutschen Nordseeküste. Probleme der Küstenforschung im südlichen Nordseegebiet 4 : 1–146.

HALLIK, R. 1949. Geologische Betrachtung zum Bohlweg im Wittmoor. Hammaburg 1 (Heft II) : 100–1.

HAMMEN, T. VAN DER. 1949. De Allerød-oscillatie in Nederland. Pollenanalytisch onderzoek van een laatglaciale meerafzetting in Drente. I en II. Proc. Kon. Nederl. Akademie van Wetenschappen, Amsterdam 52 : 69–75, 169–76.

HAMMEN, T. VAN DER. 1951. Late-glacial flora and periglacial phenomena in the Netherlands. Leidse Geol. Meded. 17 : 17–183.

IVERSEN, J. 1941. Landnam i Danmarks Stenalder. Danmarks Geologiske Undersøgelse. II. Raekke. Nr. 66.

IVERSEN, J. 1947. Plantevaekst, Dyreliv og Klima i det senglaciale Danmark. Geol. Fören. Förhandl. 69 : 67–78.

IVERSEN, J. 1949. The Influence of Prehistoric Man on Vegetation. Danmarks Geologiske Undersøgelse. IV. Raekke. Bd. 3. Nr. 6.

JESSEN, K. 1934. Archaeological dating in the history of North Jutland's vegetation. Acta Archaeologica 5 : 185–214.

JESSEN, K. 1938. Some west baltic pollen diagrams. Quartär 1 : 124–39.

JESSEN, K. 1949. Studies in the Late Quaternary Deposits and Flora History of Ireland. Proc. Roy. Irish Acad. 52B : 85–290.

JOFFE, J. S. 1949. Pedology. Second Edition. New Brunswick. 662 pp.

JONAS, F. 1933. Grenzhorizont und Vorlaufstorf. Fedde Repert. spec. nov. Beih. 71 : 194–214.

JONASSEN, H. 1950. Recent Pollen Sedimentation and Jutland Heath Diagrams. Dansk Bot. Arkiv 13 : 5–168.

JONKER, F. P. 1952. A Plea for the Standardization of Pollen Diagrams. Taxon 1 : 89–91.

KOCH, H. 1934*a*. Mooruntersuchungen im Emsland und im Hümmling. Internationale Revue der gesamten Hydrobiologie und Hydrographie 31 : 109–56.

KOCH, H. 1934*b*. Untersuchungen zur Geschichte des Waldes an der Mittelems. Bot. Jahrb. 66 : 567–98.

KOOPER, J. 1939. Het Waterstaatsverleden van de provincie Groningen. Groningen. 205 pp.

KÜNNEMANN, C. 1941. Das Sehestedter Moor und die Ursachen seiner Zerstörung. Probleme der Küstenforschung im südlichen Nordseegebiet 2 : 37–58.

LIERE, W. J. VAN. 1948. De Bodemgesteldheid van het Westland. De Bodemkartering van Nederland II. Verslagen Landbouwk. Onderz. 54.6.

LUNDQUIST, G. 1932. Tidvattnet och försumpningsetapperna. Geol. Fören. Förhandl. 54 : 305–9.

MIKKELSEN, V. M. 1949. Praestø Fjord. The development of the postglacial vegetation and a contribution to the history of the Baltic Sea. Dansk Bot. Arkiv 13 : 7–171.

MIKKELSEN, V. M. 1952. Pollenanalytiske Undersøgelser ved Bolle. In : A. STEENSBERG, Bondehuse og vandmøller i Danmark gennem 2000 ar. København. 109–33 (English Summary 299–303).

MITCHELL, G. F. 1951. Studies in Irish Quaternary Deposits : No. 7. Proc. Roy. Irish Acad. 53B : 111–206.

MODDERMAN, P. J. R. 1953. Een Neolithische woonplaats in de polder Vriesland onder Hekelingen (eiland Putten, Zuid-Holland). Berichten Rijksd. Oudheidk. Bodemond. 4, no. 2 : 1–10.

MULLER, J. en B. VAN RAADSHOVEN. 1947. Het Holoceen in de Noordoostpolder. Tijdschr. Kon. Ned. Aardr. Gen. 64 : 153–85.

NIETSCH, H. 1953. Zur Problematik des Grenzhorizonts europäischer *Sphagnum*-moore. Eiszeitalter und Gegenwart 3 : 37–46.

NILSSON, T. 1948. Versuch einer Anknüpfung der postglazialen Entwicklung des nordwestdeutschen und niederländischen Flachlandes an die pollenfloristische Zonengliederung Südskandinaviens. Lunds Universitets Årsskrift N.F. Avd. 2. Bd. 44, Nr. 7.

OVERBECK, F. 1947. Studien zur Hochmoorentwicklung in Niedersachsen und die Bestimmung der Humifizierung bei stratigraphisch-pollenanalytischen Mooruntersuchungen. Planta 35 : 1–56.

OVERBECK, F. 1952. Das Grosze Moor bei Gifhorn im Wechsel hygrokliner und xerokliner Phasen der nordwestdeutschen Hochmoorentwicklung. Bremen-Horn. 63 pp.

OVERBECK, F. und H. SCHMITZ. 1932. Zur Geschichte der Moore, Marschen und Wälder Nordwestdeutschlands. I. Das Gebiet von der Niederweser bis zur unteren Ems. Mitt. d. Provinzialstelle f. Naturdenkmalpflege 3 : 1–179.

OVERBECK, F. und S. SCHNEIDER. 1938. Mooruntersuchungen bei Lüneburg und bei Bremen und die Reliktnatur von *Betula nana* L in Nordwestdeutschland. Zeitschr. f. Bot. 33 : 1–54.

OVERBECK, F. und S. SCHNEIDER. 1940. Torfzersetzung und Grenzhorizont, ein Beitrag zur Frage der Hochmoorentwicklung in Niedersachsen. Angew. Bot. 22 : 321–79.

PFAFFENBERG, K. 1936. Pollenanalytische Altersbestimmung einiger Bohlwege am Diepholzer Moor. Nachrichten aus Niedersachsens Urgeschichte 10 : 62–98.

PLANQUE, B. A. DE. 1950. A palynological study of the Holocene and late-Glacial in South-east Friesland (The Netherlands). Rec. d. trav. bot. néerl. 42 : 41–50.

RAALTE, M. H. VAN und E. C. WASSINK. 1932. Resultate von Untersuchungen an einigen niederländischen Mooren. B. Zwartemeer. Rec. d. trav. bot. néerl. 29 : 6–12.

RADDATZ, K. 1952. Die Keramik des Barsbeker Moorfundes. Meyniana 1 : 44–9.

REINERTH, H. 1939. Ein Dorf der Groszsteingräberleute. Germanenerbe 4 : 226–42.

Roo, H. C. de. 1949. De bodemkartering van Kennemerland-Noord. Boor en Spade 3 : 167–79.

Schmitz, H. 1951. Die Zeitstellung der Buchenausbreitung in Schleswig-Holstein. Forstwiss. Centralblatt 70 : 193–203.

Schmitz, H. 1952. Klima, Vegetation und Besiedelung. Archaeologia geographica 3 : 15–22.

Schmitz, H. 1953. Die Waldgeschichte Ostholsteins und der zeitliche Verlauf der postglazialen Transgression an der holsteinischen Ostseeküste. Ber. d. deutschen Bot. Ges. 66 : 151–6.

Schroeder, D. 1930. Pollenanalytische Untersuchungen in den Worpsweder Mooren. Abh. Naturw. Ver. Bremen 28 : 13–30.

Schroeder, D. 1934. Eine *Calluna*-Heide unter der Zuidersee. Abh. Naturw. Ver. Bremen, Schütte-Festschrift : 83–7.

Schubert, H. 1933. Zur Geschichte der Moore, Marschen und Wälder Nordwestdeutschlands. II. Das Gebiet an der Oste und Niederelbe. Mitt. d. Provinzialstelle f. Naturdenkmalpflege 4 : 1–148.

Schütrumpf, R. 1951. Die pollenanalytische Untersuchung eisenzeitlicher Funde aus dem Rüder Moor, Kreis Schleswig. Offa 9 : 53–7.

Schütrumpf, R. 1952. Die pollenanalytische Horizontierung der Knochenfunde von Barsbek, Kreis Plön. Meyniana 1 : 38–43.

Schütte, H. 1927. Krustenbewegungen an der deutschen Nordseeküste. Aus der Heimat 40 : 325–56.

Schwabedissen, H. 1951. Torfstiche mit Opfergefäszen der Eisenzeit aus dem Rüder Moor, Kreis Schleswig. Offa 9 : 46–52.

Schwickerath, M. 1944. Das Hohe Venn und seine Randgebiete. Vegetation, Boden und Landschaft. Pflanzensoziologie, Band 6. Jena. 278 pp.

Selle, W. 1940. Die Pollenanalyse von Ortstein-Bleichsandschichten. Beih. Bot. Centralblatt 60B : 525–49.

Sernander, R. 1908. On the evidences of Postglacial changes of climate furnished by the peat-mosses of Northern Europe. Geol. Fören. Förhandl. 30 : 465–73.

Sernander, R. 1910. Die schwedischen Torfmoore als Zeugen postglazialer Klimaschwankungen. In : Die Veränderungen des Klimas seit dem Maximum der letzten Eiszeit. Herausgegeben von dem Exekutivkomitee des 11. internationalen Geologenkongresses, Stockholm : 197–246.

Tuinstra, U. 1951. Bijdrage tot de kennis van holocene landschapsontwikkeling in het Noordwesten van Noordbrabant. Thesis Amsterdam. 139 pp.

Veenenbos, J. S. 1949. De bodemkartering van de Friese knipgronden. Boor en Spade 3 : 76–86.

Veenenbos, J. S. 1953. Heterogenisatie van het bodemprofiel in Nederland. Boor en Spade 6 : 7–24.

Vermeer-Louman, G. G. 1934. Pollen-analytisch onderzoek van den West-Nederlandschen bodem. Thesis Amsterdam. 184 pp.

Visscher, J. 1931. Das Hochmoor von Südost-Drente geomorphologisch betrachtet. Thesis Utrecht. 108 pp.

Visscher, J. 1949. Veenvorming. Noorduyn's Wetenschappelijke Reeks. Gorinchem. 115 pp.

Vlam, A. W. 1945. Geulenkaart van het Westland. Gedenkboek Tesch. Verh. Geol.-Mijnb. Gen. Ned. Kol., Geol. Serie 14 : 525–30.

Vroman, M. 1952. Study of a Peat Profile on the Frisian Coast of the former "Zuiderzee". Acta Bot. Neerl. 2 : 250–8.

Wartena, L. 1946. Een en ander over de bodemgesteldheid van de gemeente Westdongeradeel. Tijdschr. Kon. Ned. Aardr. Gen. 63 : 451–6.

Wassink, E. C. 1939. Ueber den Grenzhorizont in niederländischen Hochmooren. Rec. d. trav. bot. néerl. 36 : 502–8.

Waterbolk, H. T. 1949. Palynologisch onderzoek van grafheuvels en oud akkerland op het Noordse Veld bij Zeijen. Nieuwe Drentsche Volksalmanak 67: 126–45.

Waterbolk, H. T. 1950. Palynologisch onderzoek van de versterking bij het Witteveen en de cultuursporen in het Bolleveen, beide bij Zeijen, gem. Vries. Nieuwe Drentsche Volksalmanak 68 : 100–21.

Waterbolk, H. T. 1954*a*. Palynological investigation of the barrow cemetery between Toterfout and Halve Mijl. Palaeohistoria 2 : 105–22.

WATERBOLK, H. T. 1954*b*. De praehistorische mens en zijn milieu. Een palynologisch onderzoek naar de menselijke invloed op de plantengroei van de diluviale gronden in Nederland. Thesis Groningen. 153 pp.

WEBER, C. A. 1900. Über die Moore, mit besonderer Berücksichtigung der zwischen Unterweser und Unterelbe liegenden. Jahres-Bericht der Männer von Morgenstern 3 : 3–23.

WEBER, C. A. 1910. Was lehrt der Aufbau der Moore Norddeutschlands über den Wechsel des Klimas in postglazialer Zeit? Zeitschr. d. deutschen Geol. Ges. 62 : 143–62.

WEBER, C. A. 1926. Grenzhorizont und Klimaschwankungen. Abh. Naturw. Ver. Bremen 26 : 98–106.

WEBER, C. A. 1930. Grenzhorizont und älterer *Sphagnum*torf. Abh. Naturw. Ver. Bremen 28 : 57–65.

WEBER, H. A. 1918. Über spät- und postglaziale lakustrine und fluviatile Ablagerungen in der Wyhraniederung bei Lobstädt und Borna und die Chronologie der Postglazialzeit Mitteleuropas. Abh. Naturw. Ver. Bremen 24 : 189–267.

WIGGERS, A. J. 1950. Enige opmerkingen over de holocene geschiedenis van Groningen en Friesland. Tijdschr. Kon. Ned. Aardr. Gen. 67 : 382–8.

WILDVANG, D. 1934*a*. Das Pollendiagramm des Berumfehner Moores. Jahrb. d. Preusz. Geol. Landesanst. 54 : 204–10.

WILDVANG, D. 1934*b*. Versuch einer stratigraphischen Eingliederung der ostfriesischen Marschmoore ins Alluvialprofil und die sich dabei ergebenden Folgerungen in Bezug auf Bodenschwankungen. Jahrb. d. Preusz. Geol. Landesanst. 54 : 642–85.

ZEIST, W. VAN. 1950. An Investigation into the earlier Vegetation of Central Friesland (The Netherlands). Rec. d. trav. bot. néerl. 42 : 28–40.

ZEIST, W. VAN. 1954. Pollenanalytisch onderzoek van de grafheuvelgroep op de Emelange bij Wijster, gem. Beilen. Nieuwe Drentsche Volksalmanak 72 : 181–9.

ZWILLENBERG, L. O. und J. HENDRIKS. 1954. Zum Vorkommen von *Cardium*klei in Waterland nordöstlich von Amsterdam. Geologie en Mijnbouw N.S. 16 : 105–17.

GLASBERGEN, W. 1954. Barrow excavations in the Eight Beatitudes. Thesis Groningen. Part I, 134 pp.; Part II, 204 pp.

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TARAXACUM SECTIO VULGARIA Dt. IN NEDERLAND I

DOOR

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De *Vulgaria* omvatten een zwerm van kleine soorten, waarvan er vele ook in Nederland voorkomen. In Nederland zijn zij vermoedelijk alle apomictisch, in het buitenland zijn er een paar uitzonderingen op apomixie gevonden. De apomixie moet uitermate volledig zijn bij deze soorten; nog nooit is een kruising in cultuur tot stand gekomen en ook in de vrije natuur wijst niets er op dat zulke kruisingen in waardeerbare mate voorkomen. Deze kleine soorten zijn uitermate constant in hun eigenschappen en algemene habitus; het milieu, waarin zij groeien, kan daarbij enige spreiding veroorzaken, maar de specifieke eigenschappen blijven ongestoord. Het grote aantal soorten, dat onderscheiden kan worden in de *Vulgaria*, leidt tot grote verwantschap van vele hunner, terwijl daarnaast ook uitermate grote verschillen kunnen optreden, verschillen, die niet minder zijn dan die, welke bij "goede" soorten in vele plantengeslachten voorkomen.

Specifieke kenmerken worden gevonden in vrijwel alle delen van de plant; vorm en kleur van bladen en bladstelen, omwindselbladen, lintbloemen, stempels en stijlen, vruchten spelen daarbij o.a. een grote rol. De eigenschappen van het blad en van de vrucht zijn bijzonder moeilijk onder woorden te brengen en vragen, bij het beschrijven van de soort, een grote uitvoerigheid. De taal is vaak onvoldoende paraat om deze kenmerken scherp en kort te omschrijven; men kan zich afvragen of het dan wel zin heeft met deze kenmerken in de taxonomie rekening te houden. Naar mijn mening moet dit wel het geval zijn: in de taxologie mag men zich niet laten begrenzen door tekortkomingen, als hierboven zijn genoemd. Het in zich opnemen van deze karakteristieke kenmerken der soorten is daarom in vele gevallen niet gemakkelijk en eist lange studie en het gebruik van veel vergelijkingsmateriaal uit herbaria en van afbeeldingen, waarin de gestalte tot uiting komt. Op het ogenblik, dat men zich deze karakteristieke gestalte "eigen" heeft gemaakt, is de soort plotseling tot iets duidelijks geworden, zodanig dat men planten vaak van meters afstand in de natuur kan herkennen.

In de scandinaafse en baltische landen hebben talrijke onderzoekers zich aan de *Vulgaria* gewijd: RAUNKIAER, DAHLSTEDT, LINDBERG f., PALMGREN, MARKLUND, HAGLUND, CHRISTIANSEN, SAARSOO, e.a.;

honderden van deze kleine soorten zijn door hen beschreven. Velen hebben ook belangwekkende beschouwingen over de genese en vermoedelijke evolutie dezer groep geschreven, b.v. MARKLUND (12).

De *Vulgaria* bezitten hun grootste dichtheid, kwalitatief en kwantitatief, in N.W. Europa. Nabij de poolcirkel worden de *Vulgaria* vervangen door de nabijstaande groep der *Boreigena* (Dt.) Hgl.; naar het Oosten van Europa sterft de groep in Rusland vrijwel uit en is ongetwijfeld in N. Azië zeldzaam, wellicht zeer zeldzaam. In midden-Europa zijn de *Vulgaria* nog talrijk aanwezig, maar toch sterk verminderd; in het Middellandse Zeegebied treden zeer weinige *Vulgaria* op. In westelijk Europa ligt in midden-Frankrijk ongeveer de grens van algemener en zeldzamer voorkomen van deze groep. In de Britse eilanden sterft de groep in de richting van Schotland uit. Buiten Europa zal men in de buurt van de menselijke cultuur veel *Vulgaria* aangevoerd vinden; in de oostelijke Verenigde Staten b.v. zijn zij min of meer ingeburgerd. Het zal niet verwonderen dat van de vele soorten uit Nederland het verspreidingsgebied zich uitstrekt van de baltische landen tot midden-Frankrijk; sommige hebben een nog kleiner areaal. In de scandinaafse en baltische landen treft men voorts nog vele soorten aan, die een meer typisch oostelijk areaal bezitten en niet in westelijk Europa voorkomen.

In Nederland zijn de meeste *Vulgaria*, als bewoners van kort grasland, zeer sterk aan de anthropogene sfeer gebonden en dikwijls, dank zij deze invloed, in het gehele land algemeen. Maar talrijke soorten zijn nog gedeeltelijk vrij hiervan gebleven of hebben zelfs de mens en zijn cultuur zoveel mogelijk ontvlucht.

Een aantal der *Vulgaria* verkiest de zure, slecht afgewaterde, soms brakke, graslanden, waaronder blauwgraslanden en onlanden; bij het gebruik van kunstmest en van andere kunstmethoden in de landbouw verdwijnen zij. Een aantal andere soorten verkiest soms licht beschaduwde zandgronden, zowel in de duinen als in het pleistocene zandgebied. Bij al dergelijke soorten zijn geografische en sociologische bijzonderheden nog op te merken, al vertroebelt de mens in Nederland wel heel veel hiervan door zijn geraffineerde greep op de natuur.

In het Nederlandsch Kruidkundig Archief 52 (1942) heb ik 4 soorten der *Vulgaria* behandeld: *T. copidophyllum*, *T. gelertii*, *T. lucidum* en *T. tenebricans*; dit was een eerste poging om iets over de verspreiding van de soorten van deze moeilijke groep in Nederland te vermelden. In deze studie, waarin ik 16 soorten behandel, zijn ook de vier genoemde opgenomen, omdat van hen zeer veel meer bekend is geworden; het ligt in mijn bedoeling deze publicatie te vervolgen.

Met dr G. HAGLUND maakte ik in 1949 een excursie van 2 weken door het land, waarbij ik zeer veel van hem leerde op het gebied der *Taraxaca*; hem ben ik bijzonder veel dank verschuldigd; ook breng ik gaarne dank aan dr B. SAARSOO, met wien ik belangrijke uitwisseling van gedachten had.

In Nederland staat uit de groep der *Taxaraca Vulgaria* niet heel veel meer herbarium-materiaal ter beschikking dan wat zich in mijn

herbarium bevindt; de korte verzameltijd, het moeilijk drogen en ook geringe belangstelling voor een "gewoon" iets zijn daar redenen voor; temeer ben ik dankbaar dat toch enkele floristen mij hebben willen helpen door het verzamelen van materiaal; hun namen vermeld ik in de vindplaatsenlijsten. Zelf heb ik, om een geografisch inzicht te krijgen, veel uitgestrekte excursies door het gehele land gemaakt, veelal vergezeld van een helper; de heren K. B. v. Brakel en P. D. Groot, die ik voor deze onvermoeibare hulp zeer dankbaar ben, leerden als niet-florist talrijke vormen in het veld onderscheiden.

Aan de korte beschrijving, die bij de verschillende soorten is gevoegd en alwaar voor de bladvorm naar figuren wordt verwezen, moet slechts een oriënterende betekenis worden toegekend. Voor een uitvoerige beschrijving wordt verwezen naar de originele, zoals de auteurs die geven.

Normaal hebben de *Vulgaria* het bezit van stuifmeel; de stijlen en stempels zijn meest groenig of vuilig geel; de aanloop aan de achterzijde van de buitenste lintbloemen is in het algemeen blauwig grijs, de kleur van de lintbloemen overigens donkergeel. De buitenste omwindselbladen hebben een verschillende stand t.o.v. het omwindsel, maar meestal zijn zij teruggebogen met iets opgerichte top. Veelal is de bladsteel rood gekleurd. Indien de soort deze "normale" eigenschappen bezit, is dit meestal niet in de korte beschrijving vermeld.

Afkortingen

B.	K. B. van Brakel
F.	D. Franke
G.	P. D. Groot
H.	G. E. Haglund
P.	D. T. E. van der Ploeg
S.	J. L. van Soest
h	herbarium; vergelijk voor afkortingen ook Index Herbariorum, J. Lanjouw en F. A. Stafleu.
!	niet in herbarium opgenomen materiaal, dat door van Soest is gecontroleerd.
!!	idem, door Haglund en van Soest gecontroleerd.

1. **Taraxacum acutangulum** Marklund, Acta Soc. F.F.F. 55.5 (1925) c. icon.; — *T. stenospermum* Dahlstedt, 1926; — *T. oxyodon* Christiansen, 1934, 1936, c. icon.

Korte beschrijving. Buitenste omwindselbladen smal (2–3 mm), stijf teruggeslagen; bladsteel rood en soms iets gevleugeld, bladvorm volgens fig. 1 met spitse lobben, de eindlob bij de buitenste bladen vaak groot (fig. 1 links).

Areaal: Finland (8), Estland en Letland (12), Zweden (8), Noorwegen (9), Denemarken (13); Duitsland : Rügen (7); Nederland, Frankrijk (19), Zwitserland !, Spanje (18); in Portugal aangevoerd (17).

Nederland. Meest op zandgrond: in de zeeduinen en op pleistoceen zand; soms met zand langs wegen elders aangevoerd; zelden op kleigrond*.

Fig. 1. T. acutangulum; a Texel, b Waalsdorp.
0.6 × (ware grootte)

Fig. 2. T. adami; a Zuidbuurtwetering, b Wassenaar, c Zwartsluis.
0.6 × (ware grootte)

Texel: den Burg en staatsbossen *H. & S.* (h); Castricum *S.* (h); Katwijk *de Jongh & S.* (h); Voorschoten *H. & S.* (h); Wassenaar, Waalsdorp, Scheveningen, Kijkduin, Hoek v. Holland, aangevoerd met zand bij Delft *S.* (h).

Nijehorne, Weende, Noordsleen, Schoterzijl* *B. & S.* (h); Soerel *H. & S.* (h); Wessinge!!; Nunspeet, Wissel, Goor-Markeloo, Diepenheim *S.* (h); Grebbeberg *B. & S.* (h); Eembrugge* *S.* (h); Geulhem* *G. &S.* (h).

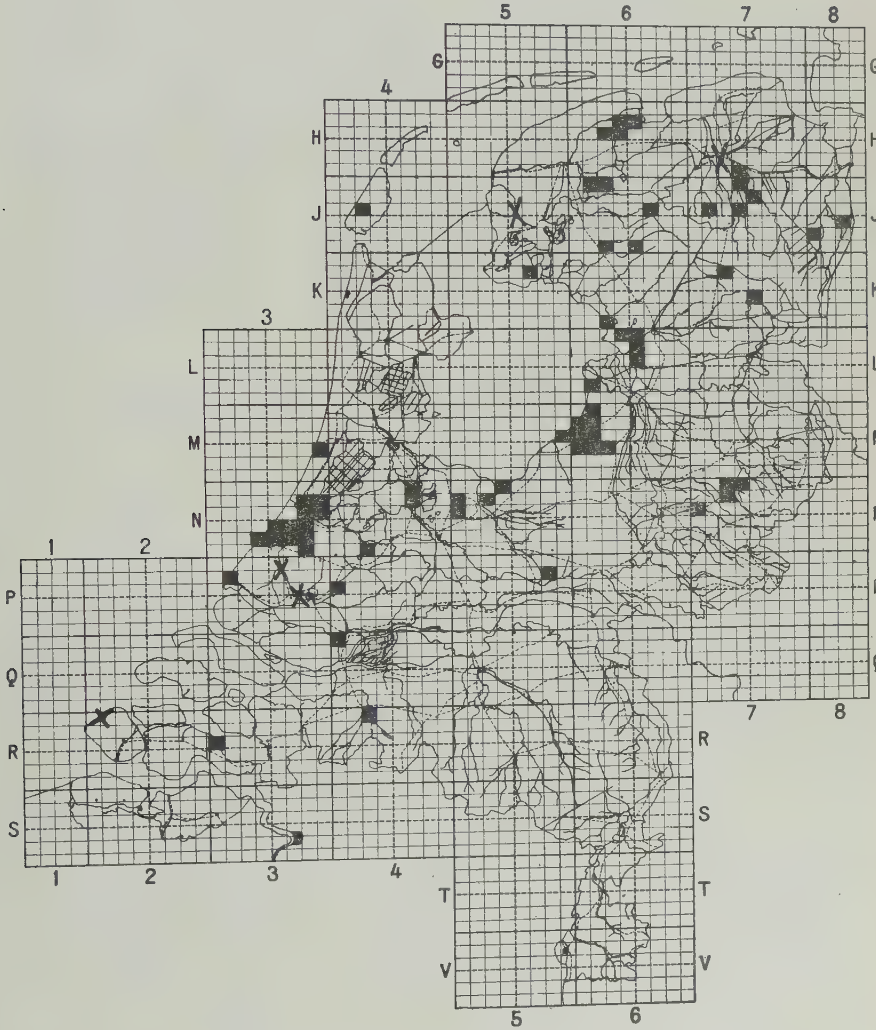
2. **Taraxacum adami** Claire, Bull. Soc. bot. Rochel. 12 (1890) 49; v. Soest, Vegetatio, 1954; — *T. gelertii* Raunkiaer, Botan. Tidskr. 25 (1903) 110; Dahlstedt, Botan. Not. (1905) 158; v. Soest, Ned. Kr. Arch. 52 (1942) 232 c. icon.

Exsiccata: Magnier 3047 (*T. adami*); Dahlstedt III 36, V 17, 18 (*T. gelertii*); Lindberg 1504, 1505 (*T. gelertii*); Lejeune 841 (*Leontodon taraxacum v. palustre*).

Korte beschrijving. Eivormige, duidelijk-witgerande buitenste omwindselbladen, die min of meer tegen het omwindsel zijn aangedrukt; bladsteel rood; bladvorm volgens fig. 2, met korte zijlobben, waarvan de top vaak iets omhooggericht is.

Kaart 1. Areaal van T. adami.

Areaal: zie kaart 1; Finland (12), Estland (14), Letland (15), zuidelijk Zweden (10), Noorwegen (9), Denemarken (13) en Bornholm (5), uiterst noordelijk (7) en westelijk Duitsland: Wachenheim, *G. F. Koch* (h.P, det. *S.*); Nederland (16), België (16), Frankrijk (19), Engeland? (4), Portugal? (17).



Kaart 2. Verspreiding van T. adami, volgens gegevens van het I.V.O.N.

Nederland. Algemeen, met uitzondering van in het Zuid-Oosten (kaart 2). Vooral in vochtige weilanden massaal optredend en begeleid door *Taraxaca* uit de groep *Palustria* en b.v. door *T. bracteatum, intermedium, lucidum*; hier lijkt *T. adami* op een natuurlijke standplaats te groeien: blauwgrasland en onland, in de drogere gordel, die aan de

Caltha-weide aansluit. Merkwaardigerwijs komt *T. adami* ook in lichte bossen voor, b.v. in de zeeduinen; in Frankrijk heeft zij voor bos de voorkeur. Zilte grond mijdt deze soort. In litt. 16 zijn reeds een aantal vindplaatsen vermeld, waarvan Groesbeek en Veenkampen onjuist waren; aanvullingen volgen hieronder.

Akkerwoude, Dantumawoude, Zwaagwesteinde, Borken, Hale, Ee-Walddijk *P.* (h); Eernewoude *B., F.* (h) *P.* (h) *& S.*; Duurswoude *B., F., P.* (h) *& S.*; Oudega *B., F., P.* (h) *& S.* (h); Norg, Elsloo (Dr.), Oldehorne-Oldeberkoop, Onnen, Beilen-Westerbork *B. & S.* (h); Orvelte!, Zweelo!, Oranjewoud!, Oudemolen!, Zuidlaren!; Zuidlaardermeer *S.* (h); ter Haar!; Adderhorst, Weende, Musselkanaal *B. & S.* (h); Schoterzijl, Muggebeet, Vollenhove, Meppel, Zwartsluis, Hasselt *B. & S.* (h); Goor, Markeloo, Stokkum, Diepenheim *S.* (h); Lochem *Viola v. Soest* (h.*S.*); Wissel, Soerel, Wessinge, Doornspijk, Elburg, Nijkerk *S.* (h); Hulshorst!; Eembrugge *S.* (h); Bunschoten *S.* (h., h. NBV); Veenendaal *Coops* (h); Nieuwersluis *v. Ooststroom* (h); Soesterveen, Lage Vuursche, Bilthoven *S.* (h); Bodegraven!!; Zoetermeer, Delfgauw, Capelle a.d. IJsel *S.* (h); Wieldrecht *Kloos* (h. L); Ierseke in het Moer *G. & S.* (h). Voorts in de duinen: staatsbossen in Texel *H. & S.* (h); duinen Amsterdamse Waterleiding *Gorter & S.* (h); 's Gravenhage *Posthumus* (h.L); aldaar op vele plaatsen, ook in het poldergebied *S.* (h); Scheveningen!; Wassenaar en Hoek van Holland *S.* (h).

3. **Taraxacum aequilobum** Dahlstedt, Ark. f. Botan. 9.10 (1910).

Exsiccata: Dahlstedt I 38, IV 32, VI 9; id. VI 27 (*T. gigas* Dt. ined.); Lindberg 1453.

Korte beschrijving. De buitenste omwindselbladen, die aan de voet vrij breed ($3^1/_2$–4 mm) zijn, zijn aan de top teruggebogen; het lichtgroene blad met lichtrode bladsteel heeft veel zijlobben, die weinig getand en spits zijn; de eindlob is klein (fig. 3).

Deze soort is o.a. verwant aan *T. acutangulum*, die echter teruggeslagen en smallere buitenste omwindselbladen bezit en waarbij de bladlobben sterker getand zijn. Ook is ze verwant aan *T. aurosulum* Lb. f., die minder zijlobben en een bredere eindlob bezit. Bij het onderscheiden van deze en enkele andere soorten in gedroogde toestand moet men, indien men geen karakteristiek materiaal onder handen heeft, veel vergelijkingsmateriaal ter beschikking hebben.

Areaal: algemeen in N. Europa; Finland (12); Estland, Letland en Littauen (15), Zweden (10), Noorwegen (9), Denemarken (13) en Bornholm (5); N. Duitsland: Nardewitz (7); Nederland. Onzeker meer naar het Zuiden in W. Europa.

Nederland. Vrij zeldzaam in het Gelders district op zandgrond, misschien ook in Z. Limburg gevonden.

Diepenheim, Markeloo, Stokkum en Voortse broek aldaar *S.* (h); Soerel *H. & S.* (h); Bommerig (Z. Limb.) *G. & S.* (h).

4. **Taraxacum alatum** Lindberg f., Acta Soc. F.F.F. 29.9 (1907).

Exsiccata: Dahlstedt II 18, 19; Lindberg 1454.

Korte beschrijving. Buitenste omwindselbladen 5–6 maal zo lang als breed, uitstaand tot meestal teruggeslagen. Bladsteel bleekgroen, gevleugeld; blad (fig. 4) lichtgroen, lang met forse tanden aan korte, spitse, vrij brede lobben; eindlob stomp.

Fig. 3. T. aequilobum; a Soerel, b Goor.
0.6 × (ware grootte)

Fig. 4. T. alatum; Elden.
0.6 × (ware grootte)

Areaal: Rusland en Finland (12), Estland, Letland en Littauen (14), Zweden (10), Noorwegen (9), Denemarken (8) en Bornholm (5), Duitsland (14), Nederland, België!; Engeland (4), o.a. Kent en Yorkshire, *Wilmott* (h. BM, det. *S.*); Zwitserland (3).

Nederland. Deze soort verkiest kleigrond, zowel zeeklei als rivierklei; op deze plaatsen verschijnt zij, waar ze gevonden is, in grote aantallen. In minder aantal komt zij op andere grondsoort* voor: veen, duinzand, pleistoceen zand, zelfs op mergel. In het Noorden van het land, tot aan de grote rivierdalen, is *T. alatum* vrij veel gevonden; ten Zuiden ervan enkel in Z. Limburg.

Dokkumernieuwezijlen, Munnikenzijl, Aduard, den Ham-Saaxum, Beerta Haren*, Zuidlaren*, Oostwold* *B. & S.* (h); Dollard: Hongerige Wolf *B. & S.*, (h., h. NBV); Duurswoude* *B.*, *F.*, *P. & S.* (h); Valom *P.* (h); Lhee* *B. & S.* (h); Goor-Markeloo*, Wissel*, Hierden*, Doornspijk*, Elburg *S.* (h); Terwolde *H. & S.* (h); Elden *G. & S.* (h); Ameide!!; Elst* (Utr.) *S.* (h); Purmer *H. & S.* (h), omgeving Haarlem* *Gorter & S.* (h); Scheveningen*, Waalsdorp* *S.* (h). In het Zuiden: St. Pietersberg op twee plaatsen *v. Ooststroom* (h).

5. **Taraxacum ancistrolobum** Dahlstedt, Ark. f. Botan. 10.11 (1911).

Exsiccata: Dahlstedt II 16.

Korte beschrijving. Buitenste omwindselbladen ca. 5 mm breed, uitstaand of iets teruggebogen met heropgerichte top. Bladsteel groen (zonder rose, rode of bruine kleur). Bladen voorzien van weinige, brede, vrijwel gaafrandige of zwakgetande, zeer dicht aaneensluitende lobben (fig. 5); de eindlob is meest zeer stomp.

Areaal: Finland (12) zeldzaam; Zweden (8) maar niet in het N.; Noorwegen (9), zeldzaam tot in het N.; Denemarken (13) plaatselijk; Nederland; België!, Engeland (4–1933), o.a. Ledbury *Campbell* (h.BM det. *S.*).

Nederland. In Nederland algemeen op zand, klei en veen; in weiland, langs wegen, in de duinen, enz. In het Zuiden van het land misschien wat zeldzamer.

Oudeschild!!, de Koog!!; Oostmahorn, Walddijk-Ee, Westergeest-Ee, Murmerwoude P. (h); Dokkumernieuwezijlen!, Oldenhove (Gr.)!, Aduard!, Muntendam!, Termunterzijl!, Dollard: Hongerige Wolf *B. & S.* (h); Eernewoude en Duurswoude *B.*, *F.*, *P. & S.* (h); Oranjewoud!, Oldehorne-Oldeberkoop!, Onnen (Gr.)!, Noordlaren!, Borger!, Buinerveen!, Musselkanaal!, ter Haar!, Dwingelo!, Zweelo!, Rode Klif!, Oudega-Nijega!, Mirdam!, polder Mastenbroek en Elburg *B. & S.* (h); Nunspeet!, Soerel!!, Terwolde!!; Epse *G. & S.* (h); Goor en Stokkum *S.* (h); Ilpendam!!, Volendam!!, Monnikendam!!, Uitdam!!, Schellingwoude!!; Amsterdam *G.* (h. *S.*); Castricum en Wijk a. Z. *S.* (h); Haarlemse duinen *P. Jansen* (h. *S.*); Heemstede *Brand* (h. NBV); Bennebroek!!; Leiden *S.* (h); Voorschoten!!; 's Gravenhage, Scheveningen, Wassenaar en Loosduinen, Hoek v. Holland, Rockanje, den Briel, Rozenburg, Vlaardingen, alle *S.* (h); Waalhaven *B.* (h. *S.*); Rotterdam *Danser* (h. NBV); Poeldijk!!, Hondsholredijk!!; Delft, Nootdorp, Voorburg, Veur *S.* (h); Hoofddorp *H. & S.* (h); Leiderdorp!!, Koudekerk!!, Woubrugge!!, Rijnsaterwoude!!, Leimuiden!!, Dordrecht!!, Alblasserdam!!, Oud-Alblas!!; Capelle a.d. IJsel *S.* (h); Ameide!!, Ochten a.d. Waal *Coops* (h); Engelen, Lent, Oosterhoutse Bos, Wageningen, Grebbeberg, Elst (Utr.) en Darthuizen *S.* (h); Maarn!, Doorn!, Zeist!; Jutphaas *B.* (h. *S.*); Biezelinge!, Goes!; Kruiningen-Ierseke en Kloetinge *G. & S.* (h); Breda *S.* (h); Valkenburg en Mechelen (Z. Limb.) *G. & S.* (h).

Fig. 5. T. ancistrolobum; Meijendel.
0.6 × (ware grootte)

Fig. 6. T. bracteatum;
a de Koog,
b Scheveningen.
0.6 × (ware grootte)

Var. **rubrostriata** van Soest **nov. var.**

Ligulae marginales extus stria rubropurpurea notatae.
Veenkampen (Grebbe) 1941 *v. Soest* (h. 12926), typus.

6. **Taraxacum bracteatum** Dahlstedt, Ark. f. Botan. 19 (1925).

Exsiccata: Dahlstedt V 20, 21.

Korte beschrijving. Omwindsel donkergroen met aan de top meest purper-gekleurde blaadjes; de buitenste, los-aanliggende omwindselblaadjes zijn vaak getand tot diep gespleten met enige smalle slipjes; ook de purperen hoofdjessteel voert boven vaak bracteën van dergelijke vorm, eveneens vaak purper-gekleurd. De bladen zijn meest donkergroen, maar soms ook lichter, de steel en het benedendeel van de middennerf zijn donkerpurper; voor de bladvorm, zie fig. 6.

Areaal: Z. W. Finland (8); Z. Zweden (10) met inbegrip van Oeland (Dahlstedt l.c.); Z. W. Noorwegen (9); Denemarken (13) en Bornholm (5); N. Duitsland: Lübeck (7); Nederland; België!; N. W. Frankrijk: Manche!, Orne!, Seine et Oise! (9); Engeland! (4).

Nederland. Op zure graslanden, waarschijnlijk als meest natuurlijke standplaats; vrij algemeen, maar plaatselijk (op zulk terrein) nog niet gevonden, b.v. niet in Friesland. Als gevolg van het menselijk verkeer e.d., is zij ook elders aangetroffen, zelfs ook op basische bodem.

Op zout terrein (b.v. Volendam) groeit zij tezamen met *Armeria maritima*, *Aster tripolium* en *Triglochin maritima*; in blauwgraslanden vindt men haar met Cyperaceëen en Juncaceëen, b.v. *Carex panicea*. In veenweiden komt zij voor met *Hierochloa odorata* en *Poterium officinale*. Zij treedt op zulk terrein vaak op met andere *Taraxaca*, in de eerste plaats uit de *Palustria*-groep, voorzover deze niet reeds voor de eerste bemestings-maatregelen zijn gevlucht: *T. austrinum*, *T. limnanthes* en vooral *T. hollandicum*, welke laatste het langste aan kunstmest weerstand biedt. In de tweede plaats kan men haar ook vinden met *T. nordstedtii* (groep *Spectabilia*) en ten slotte is zij in het algemeen door veel *Taraxaca* uit de groep *Vulgaria* begeleid, waarbij zij het trouwste gezelschap heeft b.v. van *T. adami*, *intermedium*, *lucidum*, *tenebricans*, e.a.

Volendam, zilt weiland *H. & S.* (h); Schellingwoude, zuur land *H. & S.* (h); Woerden in de Kattebroekpolder in veenweide *S.* (h); Bunschoten–Nijkerk in veenweide *B. & S.* (h); Hoophuizen bij Hulshorst op nog iets brakke grond *S.* (h); ten Z. van Elburg in het Goor *H. & S.* (h); idem ten N. van Elburg in zure, vroeger brakke weiden *S.* (h); Mastenbroekpolder, nabij het Zwarte Water *B. & S.* (h); Meppelerdiep tussen Zwartsluis en Meppel, in veenweide *B. & S.* (h); Blokzijl *B. & S.* (h.); Sellingen in Westerwolde *B. & S.* (h.) in veengebied; Oeffeltse broek *J. Jansen & Th. Reichgelt* (h); Ulvenhout *S.* (h); Hollands Diep *Kloos* (h. *S.*); Hoek v. Holland langs de N. Waterweg *S.* (h); Ierseke in het Moer en bij Biezelinge *G. & S.* (h.).

Elders, niet op natuurlijke standplaats: Texel: de Koog *H. & S.* (h); duinen van de Amsterdamse waterleiding *Gorter & S.* (h); Wijk a. Z. *S.* (h); 's Gravenhage en Scheveningen *H. & S.* (h); Nunspeet *S.* (h); wegkant Soerel!! met planten uit het Zuiderzeegebied; Heerlen *Gorter* (h); Geulhem *G. & S.* (h).

7. **Taraxacum caudatulum** Dahlstedt, Ark. f. Botan. 9.10 (1910).

Exsiccata: Dahlstedt I 36; Lindberg 1475, 1476.

Korte beschrijving. Hoofdjes in het algemeen weinig stralend; buitenste omwindselbladen teruggebogen, naar de top toe rose, met een doorschijnende rose rand van onregelmatige dikte; binnenste omwindselbladen soms met een zwak knobbeltje onder de top. Bladen (fig. 7) naar de top toe veelal in een grote eindlob verbreed, zijlobben kortdriehoekig, spits; steel rood. Onvolgroeide exemplaren vaak met bijna ongedeeld blad (fig. 7 rechts).

Door de bladvorm onderscheidt ze zich gemakkelijk van een aantal verwante soorten, zoals *T. acutangulum*, *obliquilobum*, *retroflexum* en *dahlstedtii*; vooral met de laatste is ze verwant. Al deze soorten hebben min of meer teruggeslagen buitenste omwindselbladen (die meest smal zijn) en een rode of rose bladsteel.

Areaal: Rusland en Finland (12), Estland (11), Zweden (10), Noorwegen (9), Nederland, westelijk België! Uit Denemarken en N. Duitsland is zij nog niet vermeld.

Nederland. In het bijzonder wordt zij in de zeeduinen aangetroffen in licht bos of struikgewas; op andere bodemsoort bij de Noordzeekust is zij ook nogal veel gevonden, misschien met zand uit de duinen

Fig. 7. T. caudatulum;
a Dordrecht,
b Oudeschild,
c Beverwijk.
0.6 × (ware grootte)

aangevoerd? In het N. O. van het land groeit zij op pleistocene bodem. In het Zuiden is ze in Z. Limburg één maal verzameld.

Texel: de Koog!!, den Burg!! en de Berg op pleistoceen!!; Oudeschild *H. & S.* (h); den Helder *B. & S.* (h); Beverwijk *S.* (h); Spaarndam, wegrand *B.* (h. *S.*); Scheveningen en 's Gravenhage *H. & S.* (h); Waalsdorp!; Kijkduin, Loosduinen en duinen bij Monster *S.* (h); Delft en Zevenhuizen, langs wegen *S.* (h); Waalhaven *B.* (h. *S.*); Hoek v. Holland *S.* (h., h. NBV); Staelduin en Rockanje *S.* (h); Rozenburg *H. & S.* (h); Dordrecht *H. & S.* (h); Moerdijk *S.* (h); Zwake en Kruiningen *G. & S.* (h).

Zuidlaren, Klenke-Overhesselen en ter Haar *B. & S.* (h); Staart van Urk *Bakker* (h); Nunspeet *S.* (h); Doornspijk!!, Soerel!!; St. Pietersberg *v. Ooststroom* (h).

8. **Taraxacum copidophyllum** Dahlstedt, Ark. f. Botan. 9.10 (1910); v. Soest Ned. Kruidk. Arch. 52 (1942) c. icon., pro *T. copidophyllo* et *T. maculigero.*

Exsiccata: Dahlstedt V 19; Lindberg 1478; Callier Fl. Siles. 1100 (*T. palustre x officinale*).

Korte beschrijving. Omwindselbladen aanliggend tot iets afstaand, eivormig, onduidelijk gerand. Eindlob der bladen zeer lang, vaak een groot deel van het smalle blad uitmakend (fig. 8); bladlobben weinig getand; bladsteel rood.

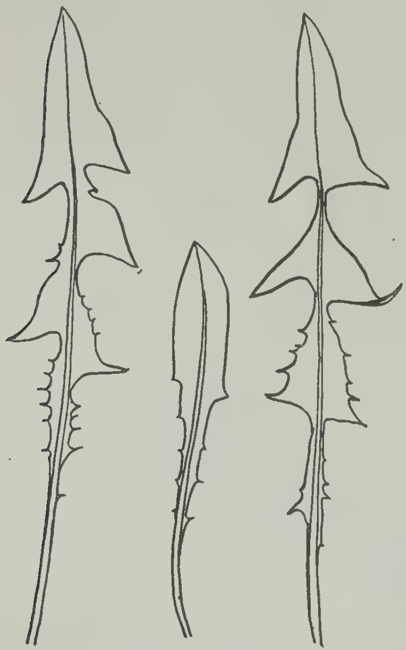


Fig. 8. T. copidophyllum; Kampen.
0.6 × (ware grootte)

Areaal: Finland (12); Z. en midden Zweden (10); Noorwegen (9); Denemarken (13) en Bornholm (5); Duitsland (12), o a (?) Bojanowo in Posen, *C. Scholz* exs. Callier l.c. (h.L, h.P, det. *S.*).

Nederland. In zure, vochtige weilanden in het N. en het midden van het land, veel tezamen met *Palustria* en met *T. adami*, *tenebricans*, e.d.

Langs de kust van de Dollard: Oostwold, aan de binnenzijde van de dijk *B. & S.* (h., h. NBV); idem bij de Hongerige Wolf *B. & S.* (h); Akkerwoude, Heechfinne *B., F., P.* (h) *& S.* (h); Eernewoude *B., F., P.* (h) *& S.*; Vollenhovense meer *Bakker* (h); Kampen aan de buitenzijde van de Zwartendijk, vroeger ziltig *S.* (h); langs de Garste (Kampereiland) *S.* (h); Doornspijk, vochtig land buiten de Kerkdijk *S.* (h); Goor ten Z. van Elburg en zure weilanden ten N. van Elburg *S.* (h); Harderwijk, weiden langs de Zuiderzee *S.* (h); Goor in de Grote Whee *S.* (h); bij Huis te Merwede *Kloos & S.* (h).

Opmerkingen

1. De planten kunnen zeer in grootte wisselen; die op kleigrond zijn forser, die op veengrond teerder. De laatste vertonen soms bladen, die in de jeugd minder lang zijn, speciaal wat de eindlob betreft. Bovendien vertonen zij, voornamelijk in de herfst en in het vroege voorjaar soms weinige tot vrij talrijke purperen vlekjes op de bladen, die noch verward moeten worden met vaak purperen vlekjes, die door beschadiging kunnen ontstaan, noch met de purperen kleur, die stukken van het interlobium bij een aantal *Vulgaria* kunnen vertonen. Deze vlekjes treden, meest in veel groter aantal bij de meeste *Spectabilia* op, echter niet bij de Nederlandse soorten, w.o. *T. nordstedtii*, die overigens in de *Spectabilia* ook een uitzonderlijke plaats inneemt. Deze vlekjes, en ook wel de algemene habitus van deze kleine vormen, heeft mij in N. K. A. 52 verleid hen met *T. maculigerum* Lb. f. te vereenzelvigen, hetgeen onjuist is gebleken. Of deze planten, minnaars van ziltig-zurige vochtige weilanden en groeiend in het Zuiderzeegebied, een afzonderlijke soort vormen, moet nog onzeker blijven; planten in cultuur op klei gebracht, behouden de vlekken zeer goed, maar ze worden habitueel zo fors als de normale *T. copidophyllum*. Ik zag planten met vlekjes van: Zwartendijk, Garste, Elburg, Doornspijk en Harderwijk.
2. Andere planten, eveneens van kleine postuur, kan men in de veengebieden van Friesland vinden; deze vertonen zoveel gelijkenis met een soort der *Palustria* (*T. frisicum* ined.), dat ze enige tijd door mij verward zijn. Bij nader inzien komen echter toch duidelijke verschillen tevoorschijn; *T. frisicum* heeft smallere eindlob, de buitenste omwindselbladen hebben de voor de *Palustria* zo karakteristieke ietwat vage, maar brede doorschijnende rand; voorts is de hoofdjessteel geheel kaal; wellicht het meest specifiek is de cylindrische vorm van de vruchtconus. Ik heb deze vorm van *T. copidophyllum* tijdelijk *T. pseudofrisicum* genoemd; inderdaad verschilt ze iets van *T. copidophyllum* door minder gestekelde vruchten, door het totaal aangedrukt zijn der buitenste omwindselbladen tegen het omwindsel en, zoals gezegd, door de kleine afmeting van de plant. Voorlopig behandel ik deze vorm (?) als identiek met *T. copidophyllum.*

Uit Engeland zag ik enkele planten uit Marston, *Chapple* (h.BM en h.K) als *T. anglicum* Dt. gedetermineerd; deze planten behoren daar niet toe, maar gelijken op de hierboven beschreven vorm. Een nader onderzoek is nog gewenst.

9. **Taraxacum cordatum** Palmgren, Acta Soc. F.F.F. 34.1 (1910) c. icon; Haglund Botan. Not. (1934) p. 382; — *T. amblycentrum* Dahlstedt, 1911; — *T. cophodon* Dahlstedt mscr.

Exsiccata: Dahlstedt I 27, II 29, V 8 (*T. amblycentrum*); III 30 (*T. cophodon*).

Korte beschrijving. De eilancetvormige buitenste omwindselbladen zijn los aanliggend of afstaand en bruin (niet purper). De bladsteel is rood; bij normaal ontwikkelde planten is de bladvorm (fig. 9) zeer opvallend; de bladslippen zijn regelmatig geplaatst, weinig getand, enkele soms aan de top cirkelvormig afgerond; dit laatste is een eigenschap, die bij enkele andere soorten ook voorkomt.

Fig. 9. T. cordatum; Wassenaar. 0.6 × (ware grootte)

Areaal: Finland (12); Estland, Letland en Littauen (15); Z. Zweden (10), Noorwegen (9), Denemarken (13) en Bornholm (5), N. Duitsland (7), Nederland, België!, Engeland (Oxford *Linton* en Burnham *Alston*, h. BM, det. *S.*), Ierland (*Degelius* h.K, det. *H.*), Spanje (18).

Nederland. Deze soort verkiest zandige grond, maar is ook op andere bodemsoort gevonden.

Eernewoude *B.*, *F.*, *P.* & *S.* (h), Rinsumageest *P.* (h); Haren-Eelde, Gaasterland : Schoterzijl, Blankenham, Zwartsluis-Meppel *B.* & *S.* (h); Nunspeet!; Elburg, Goor-Markeloo en Grote Whee *S.* (h); Velperbroek *des Tombe* (h. L); Swalmen en Vaals *G.* & *S.* (h).

Algemeen op Texel!!, den Helder!!, Schellingwoude!!; Egmond en Castricum *S.* (h); Heemstede *Brand* (h. NBV), Bloemendaal *v. Eeden* (h. NBV), Bennebroek!!, Heemstede *Gorter* & *S.* (h), Noordwijk-Katwijk de *Jongh* & *S.* (h); Wassenaar, Waalsdorp, 's Gravenhage (ook h. NBV), Voorburg, Kijkduin, alle *S.* (h); Loosduinen!, Scheveningen!!, Rockanje!!.

10. **Taraxacum croceiflorum** Dahlstedt, Ark. f. Botan. 9.10 (1910).

Exsiccata: Dahlstedt III 27, 28; VI 1; Lindberg 1488.

Korte beschrijving. Lintbloemen van buiten roodbruin gestreept, het geel van de bloemen zelf ook iets oranje- of rood-achtig, vooral naar de top der linten; deze kleur is voor de *Vulgaria* een vrij grote uitzondering, alhoewel de aanloop van de lintbuitenzijde wel eens meer naar het rode zweemt. De bladsteel is groen; de bladvorm is vrij variabel (fig. 10); de talrijke lobben, die vaak ongelijk zijn, zijn meest sterk getand. De buitenste omwindselbladen zijn teruggebogen en van binnen groenig of iets rossig.

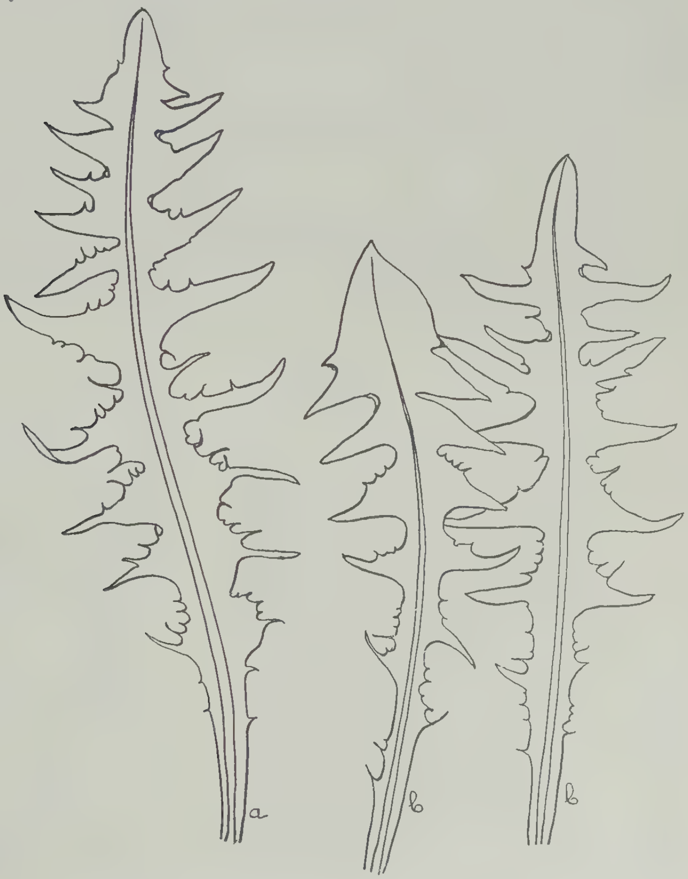


Fig. 10. T. croceiflorum; a Waalsdorp, b 's Gravenhage. 0.6 × (ware grootte)

Areaal: Rusland en Finland (12), Estland en Letland (11), Z. Zweden (10), Noorwegen (9), Denemarken (13), Nederland, Engeland!, Frankrijk (Dept. Orne) (19); niet overal algemeen.

Nederland. Algemeen en sterk onder anthropogene invloed, daardoor ook veel langs wegen, enz.; op allerlei grondsoorten.

Muntendam, Munnikenzijl, Zoutkamp, den Ham-Saaxum, Onnen *B. & S.* (h); Rinsumageest *Jansen & P.* (h), Akkerwoude *P.* (h), Vollenhove *B. & S.* (h), Stokkum en Voortse broek *S.* (h), Goor!, Doetinchem *G.* (h. *S.*), Soerel *H. & S.* (h); Nunspeet, Oldebroek, Hierden, Nijkerk *S.* (h); Otterloo *Erbrink* (h. AD); Wageningen, Grebbeberg, Rhenen, Elst (Utr.), Darthuizen *B. & S.* (h); Ewijk *J. Jansen, Kern & Th. Reichgelt* (h. *K. & R.*); Ewijk, Oosterhoutse bos, Herveld *G. & S.* (h); Bergambacht-Schoonhoven *S.* (h), Jutphaas *B.* (h. *S.*); staatsbossen Texel, de Koog, Westerduinen, den Burg en de Berg aldaar, alle *H. & S.*!!; den Helder *B.* (h. *S.*), Landsmeer *Gorter* (h); Ilpendam!!, Schellingwoude!!, Amsterdam!!, Bennebroek *H. & S.* (h), Haarlemmermeer, o.a. Hoofddorp!!, Woubrugge!!, Leiderdorp!!, Spaarndam *B.* (h. *S.*); Woerden, Warmond, Leiden, Delfgauw, Schipluiden *S.* (h); Voorschoten, Waalsdorp, 's Gravenhage *H. & S.* (h); Wassenaar *S.* (h), Scheveningen *S.* (h., h. NBV), Loosduinen *S.* (h), Schiedam *de Wilde* (h); Hondsholredijk!!, Dordrecht!!, Oud-Alblas!!, Rozenburg!!, Rockanje!!, Groe!; Ierseke, Biezelinge, Goes *G. & S.* (h); Oosterhout, Waspik, Raamsdonkveer, Engelen (N.Br.) *S.* (h); Oirschot *Hoekstra* (h. *P.*); Geulhem, Herpesch, Mechelen, Vijlen *G. & S.* (h); Neercanne *v. Ooststroom* (h).

11. **Taraxacum cyanolepis** Dahlstedt, Ark. f. Botan. 10.11 (1911).

Exsiccata: Dahlstedt I 22, V 26; Lindberg 1490, 1491, 1492.

Korte beschrijving. De buitenste omwindselbladen, die teruggebogen zijn, hebben een opvallend violette binnenkant; dit violet bevat veel blauw, meer dan bij andere soorten, waar de kleur soms paars of purper kan zijn. De steel van de karakteristieke bladen (fig. 11) is groen.

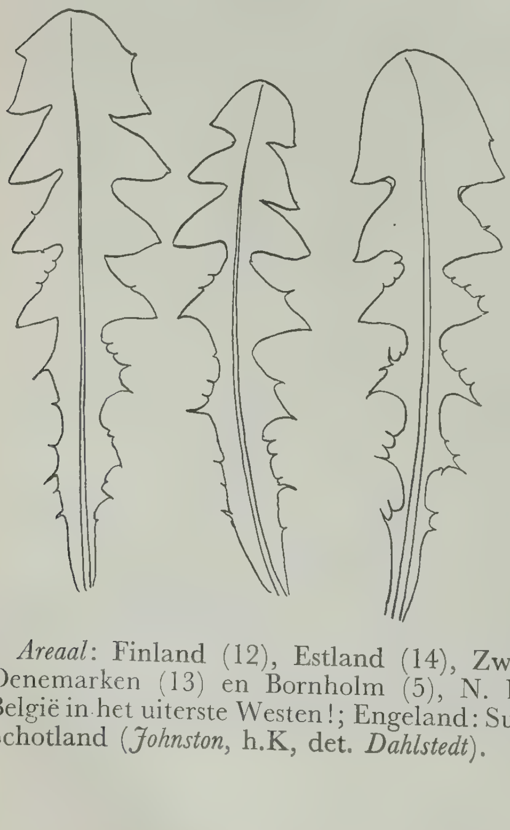


Fig. 11. T. cyanolepsis; Texel
0.6 × (ware grootte)

Areaal: Finland (12), Estland (14), Zweden (8), Noorwegen (9), Denemarken (13) en Bornholm (5), N. Duitsland (7), Nederland; België in het uiterste Westen!; Engeland: Surrey (*Alston*, h. BM, det. *S*); Schotland (*Johnston*, h.K, det. *Dahlstedt*).

Nederland. Deze soort is zeldzaam in Nederland; tot heden toe is zij veel op Texel gevonden en een paar maal in het Gelders district.

Texel: de Koog en in de staatsbossen *H. & S.* (h); Nunspeet *S.* (h); Stokkum (Ov.) *S.* (h).

12. **Taraxacum dahlstedtii** Lindberg f., Acta Soc. F.F.F. 29.9 (1907); — *T. densiflorum* Christiansen, 1936.

Exsiccata: Dahlstedt II 33; Lindberg 1493, 1494.

Korte beschrijving. De buitenste omwindselbladen zijn meest duidelijk teruggeslagen tegen de hoofdjessteel; soms zijn de toppen ervan weer iets opgericht. De bladstelen zijn rood, de bladvorm met de iets stompe, bijna ovale middelste zijlobben is zeer karakteristiek (fig. 12). In het buitenland zijn hier en daar knobbels op de buitenste omwindselbladen aangetroffen, maar in Nederland nog niet.

Fig. 12. T. dahlstedtii; a Soerel, b Voorburg, c Rozenburg. 0.6 × (ware grootte)

Areaal: Letland en Littauen (15), Estland (11), Finland en Rusland (12), Zweden, noordwaarts tot aan de poolcirkel (10), Noorwegen (9), Denemarken (13) en Bornholm (5), N. Duitsland (7), Nederland, België vermoedelijk!; Engeland (4) o.a. Yorkshire!, Surrey!; Wales (*Degelius*, h.K., det. *H.*); IJsland (2); Canada: Quebec!; Alaska aangevoerd (*H.* in Svensk Bot. T. 40.4, 1946).

Dit areaal wijkt enigszins af van de andere hier behandelde arealen door de uitbreiding in het Westen tot in Amerika; ook al zou hier sprake zijn van invoer door menselijke invloed, dan is het wel opvallend dat zij in Europa zo weinig zuidwaarts schijnt gekomen te zijn.

Nederland. Deze soort heeft voorkeur voor zandgrond; zeeduinen en pleistoceen zand; zij komt overigens ook op andere bodemsoort voor. Zij is over het gehele land verspreid.

Algemeen op Texel: de Koog, Westerduinen, staatsbossen, den Burg, de Berg, Oudeschild, alle *H. & S.* !!; den Helder!!, Beverwijk *S.* (h), Aerdenhout *Gorter* (h), Oegstgeest *de Jongh & S.* (h), Wassenaar *H. & S.* (h); Meijendel, Waalsdorp, algemeen om den Haag, Scheveningen, Kijkduin, Voorburg, Hoek v. Holland, Staelduin *S.* (h); Brielse veer *H. & S.* (h), Groene strand bij Rockanje!! Ter Apel, Weende, Vries, Tinaarlo, Rode Klif, Lyclemabos in Gaasterland, Blokzijl *B. & S.* (h); ter Haar *B. & S.* (h., h. NBV); Goor-Markelo en Nunspeet *S.* (h); Soerel *H. & S.* (h), Elst (Utr.) *B. &S.* (h); Woerden en Zevenhuizen *S.* (h); Waalhaven *B.* (h. *S.*), Oud-Alblas *H.*, *Kloos & S.* (h); Groe (Z. Bev.) *G. & S.* (h), Oosterhout *S.* (h), Mechelen (Z. Limb.) *G. & S.* (h).

13. **Taraxacum duplidens** Lindberg f., Acta Soc. F.F.F. 29.9 (1907).

Exsiccata: Dahlstedt I 49; Lindberg 1497, 1498.

Korte beschrijving. Deze soort heeft gele stempels en stijlen en mist stuifmeel, waarmede zij onder Nederlandse *Vulgaria* gekenmerkt is. *T. parvuliceps* is ook pollenloos, maar heeft groenig-gele stijlen en stempels; in Zomer- en najaarsbloei missen andere soorten ook wel eens stuifmeel. De hoofdjes van *T. duplidens* zijn iets lichter geel dan

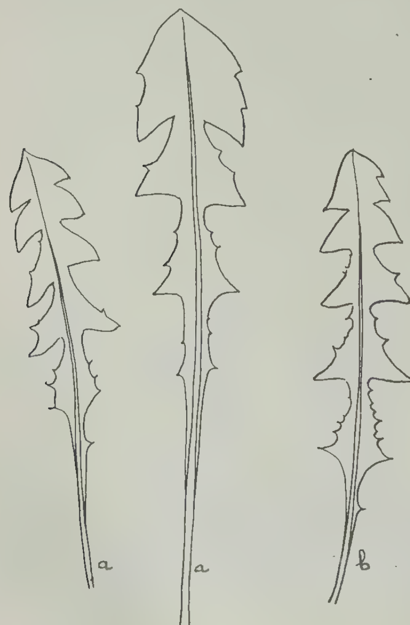


Fig. 13. T. duplidens; a Scheveningen, b 's Gravenhage. 0.6 × (ware grootte)

van de meeste andere *Vulgaria*, een kenmerk dat ook *T. parvuliceps* bezit. De bladsteel is felrood, de bladvorm is in fig. 13 afgebeeld.

Areaal: Rusland en Finland (12), Letland (11), Estland en Littauen (14), Zweden (10), Z. en midden Noorwegen (9), Denemarken (13) en Bornholm (5), N. Duitsland (7), Nederland, België!, Engeland (4)!, IJsland (2).

Nederland. Deze soort is slechts algemeen in de zeeduinen op licht beschaduwde grond in het Duindistrict, waar zij veel tezamen groeit met *T. tortilobum*, *T. lacistophyllum*, *T. duplidentifrons*, *T. trilobatum* e.d.. Op pleistocene bodem is zij zeldzamer gevonden in het Drents en Gelders district, steeds op zand.

Heemskerk, Westerhout, Wijk a. Z., Castricum *S.* (h); Amsterdam, met zand aangevoerd (? *S.*) *Tilanus* (h. NBV); duinen bij Haarlem *P. Jansen* (h. *S.*), Noordwijkerhout!, Katwijk!; Warmond, met zand aangevoerd *S.* (h); Scheveningen *H. & S.* (h); Wassenaar, Waalsdorp, 's Gravenhage op vele plaatsen, Kijkduin, Loosduinen-Monster, Hoek v. Holland *S.* (h); Hondsholredijk, met zand aangevoerd, Rozenburg en Brielse veer, Rockanje, alle *H. & S.*!!; Ierseke, met zand aangevoerd?, *G. & S.* (h).

Texel: den Burg en de Berg!!; den Helder!!; Weende *B. & S.* (h); Nunspeet, en Soerel *S.* (h).

14. **Taraxacum duplidentifrons** Dahlstedt, Reports Botan. Exch. Cl. Brit. Isl. 8 (1929); Haglund, Botan. Notiser (1936) 57; — *T. raunkiaerii* Wiinstedt in C. Raunkiaer, Dansk Eksk. Fl. (1934) en in Christiansen, Dansk Botan. Ark. 9 (1936) c. icon.

Korte beschrijving. Stijlen en stempels opvallend donkergrauw; omwindsel donkergroen met grijze glans, de buitenste blaadjes zijn los aanliggend of iets afstaand. Hoofdjessteel bovenaan dicht wollig behaard. Bladsteel vuilrood; bladen (fig. 14) dun, grijsgroen, ruwig behaard, met veel spitse, iets teruggerichte lobben.

Fig. 14. T. duplidentifrons; a Wassenaar, b 's Gravenhage. 0.6 × (ware grootte)

Areaal: Z.W. Zweden (6), Noorwegen langs de kust tot Trondheim (9); Denemarken (13) en Bornholm (5); N. Duitsland (Hamburg en Lübeck) (7), Nederland, België!; Engeland, Schotland en Orkney-eilanden (6), ofschoon ik in de herbaria uit de Britse eilanden ook andere soorten onder deze naam zag!

Nederland. Algemeen ten N.W. van de lijn Hengelo (O)–Arnhem–'s Hertogenbosch, zeldzaam ten Z.O. daarvan. De soort heeft een zekere voorkeur voor licht beschaduwde plaatsen op zandige bodem.

Haren, Zuidlaren, Tinaarlo, Vries, Adderhorst, Elslo (Dr.), Nijehorne, Gaasterland *B. & S.* (h); Borger!, Oranjewoud!, de Boorn *B., F., P., S.* (h); Goor-Markeloo, Wezep, Nunspeet, Wessinge, Hierden *S.* (h); Elburg!, Soerel!; Eembrugge, Bunschoten, Lage Vuursche *S.* (h); Hilversum-Loosdrecht en Utrecht *B.* (h. *S.*); Zeist!, Maarn *S.* (h), Darthuizen en Grebbeberg *B. & S.* (h), Bennekom *Coops* (h). Texel; de Koog!!, Westerduinen!!, Staatsbossen, den Burg!!, de Berg!!, Oudeschild!!; Callantsoog!, Volendam!!; Castricum, Wijk a. Z., Heemskerk, Beverwijk *S.* (h); Hoofddorp!!, Noordwijkerhout!!, Katwijk-binnen!; Katwijk a. Z., Leidse Hout en Oegstgeest *de Jongh & S.* (h); Woubrugge!!, Alphen!!, Voorschoten!!; in grote hoeveelheid overal tussen Wassenaar, Waalsdorp, Scheveningen, 's Gravenhage, Voorburg en Loosduinen *S.* (h); Delfgauw, Hoek v. Holland *S.* (h); Staelduin!, Dordrecht *de Wilde* (h), Alblasserdam!!, Capelle a. d. IJsel *S.* (h); Oostvoorne en Rockanje!!, Oosterhout *S.* (h), Lommerheide *Gorter* (h), Meerssen *G. & S.* (h).

var. brachyglossa v. Soest **nov. var.**

Ligula tubulosa, stylo prominente.

Waalsdorp, 1942 *v. Soest* (h. 12968), typus.

15. **Taraxacum lucidum** Dahlstedt, Ark. f. Botan. 9.10 (1910); v. Soest, Ned. Kruidk. Arch. 52 (1942); — *T. laetecolorans* Lindstroem.

Exsiccata: Dahlstedt II 24.

Korte beschrijving. Buitenste omwindselbladen eivormig, onduidelijk gerand, los aanliggend of iets afstaand. Bladsteel meest felrood, maar soms zwakker gekleurd; blad (fig. 15) met grote, brede en stompe eindlob.

Areaal: Finland en Letland (12), Estland (11), Z. en midden Zweden (10), Z. Noorwegen (9), Denemarken (13), Duitsland: Rügen (7), Nederland, België!

Nederland. *T. lucidum* is een algemene soort; op vochtige kleigrond komt zij o.a. veel voor, waar zij haar meest natuurlijke standplaats in weiden schijnt te bezitten. In brakke streken* is zij ook te vinden; daar kan men haar vinden met Palustria en verder b.v. met *Alopecurus bulbosus*, *Cochlearia officinalis* en *Ranunculus sardous*.

Akkerwoude en Rinsumageest *P.* (h), Dokkumernieuwezijlen en Munnikenzijl* *B. & S.* (h), Oldenhove (Gr.)!, Aduard!, Muntendam!, Onnen!, Musselkanaal *B. & S.* (h); Zwaagwesteinde en Ee-Walddijk *P.* (h), Eernewoude *B., F., P.* (h) *& S.* (h), Duurswoude *B., F., P.* (h) *& S.*, de Boorn en Hemrik *B., F., P. & S.* (h), Nijehorne!, Oldehorne-Oldeberkoop!, Warns!, Hemelum!, Nijega!, Mirnserklif *B. & S.* (h), Takozijl!, Lemmer!; Schoterzijl, Langelille, Muggebeet, Meppel, Zwartsluis, Hasselt, Mastenbroek, Elburg* *B. & S.* (h); Kampen* *S.* (h), Soerel *H. & S.* (h); Doornspijk, Tonsel, Maarn-Doorn, Grebbe bij Wageningen, Goor, Stokkum *S.* (h); Terwolde!!, Elden en Lent *G. & S.* (h), Zalt-Bommel *S.* (h), Jutphaas *B.* (h. *S.*), Nieuwersluis *v. Oosstroom* (h).

Den Burg, den Helder, Volendam*, Ilpendam, Monnikendam, Uitdam, Durgerdam, Schellingwoude, Leimuiden, Woubrugge, Alphen, Koudekerk, alle *H. & S.*!!;

Woerden!; Aalsmeer, Zoetermeer, Nootdorp, Delfgauw *S.* (h); Bennebroek bij de Haarlemmermeer *H. & S.* (h); Voorburg, Wassenaar, Waalsdorp, 's Gravenhage, Scheveningen, Hoek v. Holland *S.* (h); Staelduin!; Hondsholredijk!!, Dordrecht!!, Oud-Alblas!!; Huis ter Mewede *Kloos & S.* (h), Capelle a. d. IJsel *S.* (h); Rozenburg*, den Briel, Rockanje *H. & S.* (h); Goes, Groe, Biezelinge, Zwake (ook h. NBV), Kloetinge en Ierseke* *G. & S.* (h); Waspik *S.* (h); Swalmen, Geulhem, Mechelen *G. & S.* (h).

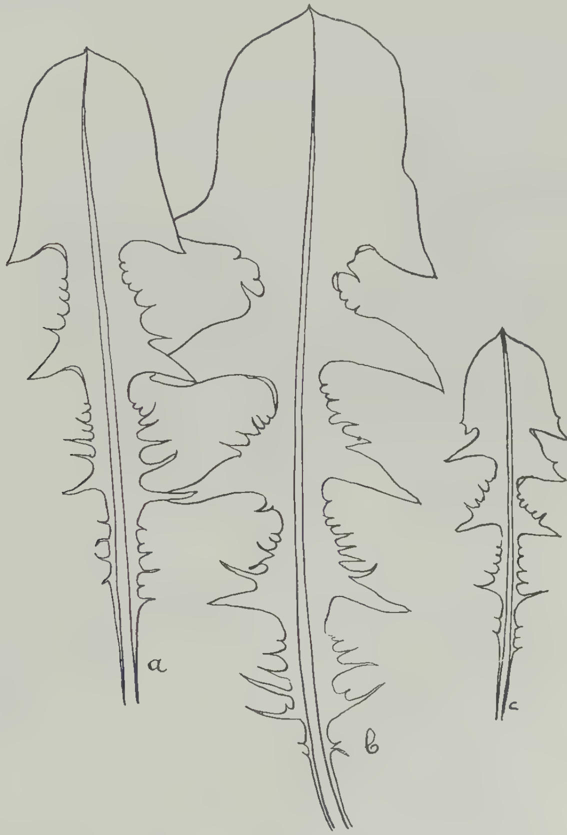


Fig. 15. T. lucidum; a Soerel, b Wassenaar, c Bennebroek
0.6 × (ware grootte)

OPMERKINGEN

1. Een vorm met roodbruine strepen op de achterzijde van de linten der buitenste bloemen is in het Oranjewoud verzameld, *B.* en *S.* (h).

2. Een vorm met kleine bladlobben, overeenkomend met *T. fulgidum* Haglund, Botan. Notiser (1938), heb ik in deze lijst als identiek met *T. lucidum* behandeld.

19. **Taraxacum tenebricans** Dahlstedt, Botan. Notiser (1905).

Exsiccata: Dahlstedt I 20, IV 22, 23; Lindberg 1571, 1572.

Korte beschrijving. Buitenste omwindselbladen eivormig, los afstaand,

soms iets aanliggend. Bladsteel groen, bladen (fig. 16) met vaak wat purperen kleuring der interlobia; tamelijk sterk gedeeld en getand. *T. tenebricans* is verwant aan *T. intermedium*, die in bladvorm aanzienlijk afwijkt, en aan *T. sublaeticolor*; de laatste heeft echter smallere, afstaande tot meest teruggebogen omwindselbladen, terwijl ook de bladvorm wat afwijkt. Deze beide soorten komen op gelijke standplaats voor als de eerste.

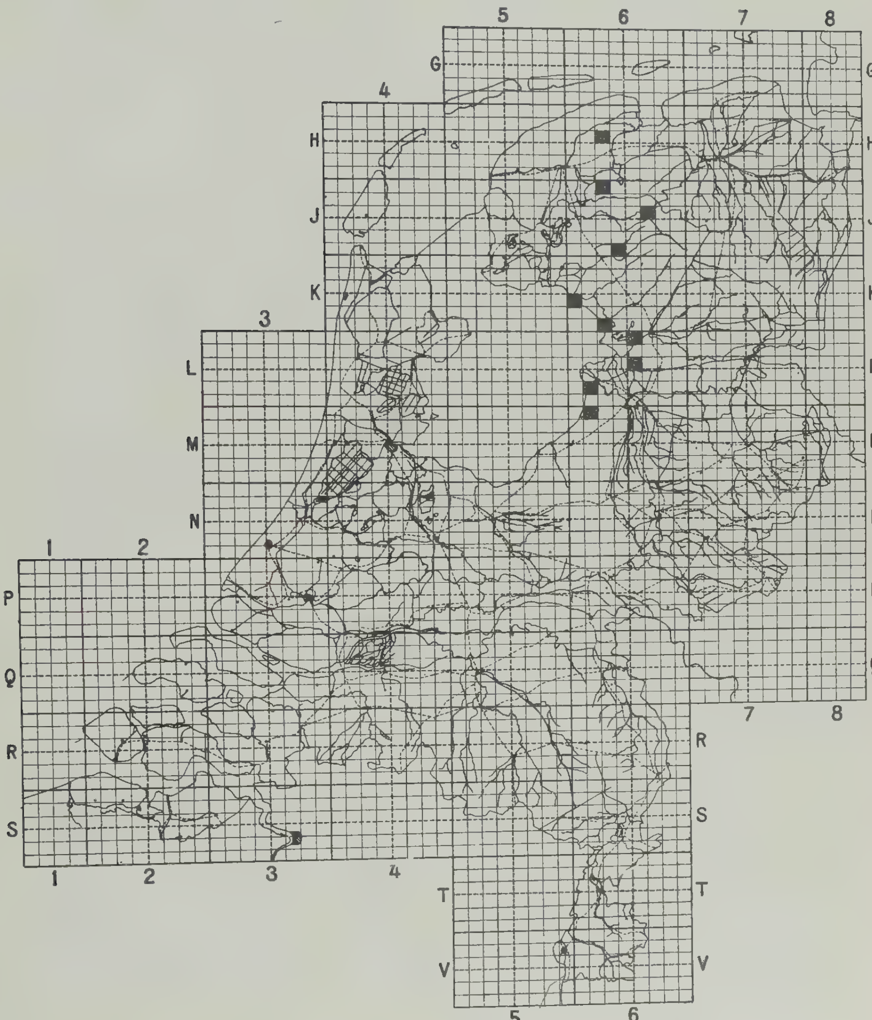
Fig. 16. T. tenebricans; Elburg.
0.6 × (ware grootte)

Areaal: Rusland, Finland en Letland (12), Littauen (15), Estland (11), Zweden (10), Noorwegen (9), Denemarken (13) en Bornholm (5), Duitsland: Rügen (7), Nederland.

Deze soort beperkt zich tot N. Europa; alleen vermeldt MARKLUND haar, zonder nadere aanduiding, van Frankrijk.

Nederland. In zure vochtige weilanden in de veengebieden; na kunstmest-behandeling en andere artificiele maatregelen verdwijnt de soort, evenals de *Palustria*, waarvan alleen *T. hollandicum* nog enige tijd stand blijkt te houden; ook *T. intermedium* verdwijnt onder zulke omstandigheden. *T. tenebricans* is alleen in het N.O. van het land verzameld (kaart 3); in Friesland is zij tezamen gevonden met *Carex panicea*, *Hierochloa odorata*, *Viola palustris*, e.d. en met *T. frisicum* (*Palustria*), *T. nordstedtii* (*Spectabilia*), *T. adami*, *T. copidophyllum*, e.d. In N.W. Overijsel en Gelderland vindt men haar met *Hierochloa odorata*, *Fritillaria meleagris*, *Sanguisorba officinalis*, enz. en met *T. austrinum*, *limnanthes*, *hollandicum* (*Palustria*), *T. adami*, *bracteatum*, *intermedium*, e.d.

Friesland: Akkerwoude *B.*, *F.*, *P.* (h) *& S.*; Eernewoude *B.*, *F.*, *P. & S.* (h); Nijehorne *B. & S.* (h); Duurswoude *B.*, *F.*, *P.* (h) *& S.* (h); Schoterzijl *B. & S.* (h)



Kaart 3. Verspreiding van T. tenebricans, volgens gegevens van het I.V.O.N.

Overijsel: Muggebeet b. Blokzijl *B. & S.* (h); Zwartsluis-Meppel langs het Meppelerdiep *B. & S.* (h); Hasselt-Zwartsluis langs het Zwarte Water *B. & S.* (h); buiten de Zwartendijk b. Kampen *S.* (h).
Gelderland: vroeger zilte landen ten N. van Elburg *H. & S.* (h).

Opmerking. Ik vermeldde deze soort in litt. 16, doch interpreteerde haar fout, zodat de daar opgegeven vindplaatsen onjuist zijn.

SUMMARY

This is the first of a series of papers dealing with the *Taraxacum* species occurring in the Netherlands. It discusses 16 species belonging to the group "*Vulgaria*", 4

of them have already been mentioned in "Nederlandsch Kruidkundig Archief" (*52* : 231–236. 1942).

The species belonging to this group vary widely in their geographic distribution but a large part of those, growing in the Netherlands, occupy an area covering part of the baltic and scandinavian countries, northern Germany, the Netherlands and Belgium and extending southwards to central France and westwards to southern England.

Human influence upon nature is very strong in the Low Countries; it has been favourable for some of these species, for others less so or not at all. A fairly large group live in districts with a sandy soil and prefer slight shade; they are more or less independant of this anthropogenic influence. Others prefer an acid and humid habitat, and play an important role in pastures, until man changes the conditions by modern dunging methods and by other artificial means.

For each of the 16 species the synonymy, icones and exsiccata are mentioned; a short description is added, accompanied by a picture of the leaf form; the total area is given as far as known at present, and this is followed by data with regard to the distribution in the Netherlands.

1. *T. acutangulum* Marklund: rather common, especially on sand and, to a slighter extent, on clay.
2. *T. adami* Claire (*T. gelertii* Raunkiaer): compare map 1 for the total area and map 2 for its distribution in the Netherlands. It is common in acid and humid pastures; under human influence also elsewhere, even in slightly shaded places in the sand districts. It avoids brackish soil.
3. *T. aequilobum* Dahlstedt: rare.
4. *T. alatum* Lindberg f.: on clay soil it often appears in large quantities; on other soils it is less common.
5. *T. ancistrolobum* Dahlstedt: common; a var. *rubrostriata* is described.
6. *T. bracteatum* Dahlstedt: in acid pastures, rather common; under human influence also elsewhere. In brackish localities it appears together with *Armeria maritima*, *Aster tripolium*, and *Triglochin maritima*; it is often accompanied by other *Taraxaca*, especially by those belonging to the *Palustria* group.
7. *T. caudatulum* Dahlstedt: especially in the dunes along the seashore, also on pleistocene sand, elsewhere rare.
8. *T. copidophyllum* Dahlstedt: in acid pastures in the northern and eastern parts of the country. It may be that *T. copidophyllum*, as treated here, will have to be split in 2 or 3 species. Besides the typical form, there is a one of smaller dimensions (though becoming taller in culture), characterized in autumn and early spring by small purple spots on the leaves; it was erroneously identified by me in N.K.A. as *T. maculigerum* Lindberg f. A third one, also of small dimensions, differing from the type by the outer bracklets of the involucre being strongly adpressed, shows some resemblance to the species of the *Palustria* group, but it certainly does not belong to the latter. The second form is found around the Zuiderzee in pastures that ten years ago were brackish but that now are no longer so; the third form has been found in peat-bog pastures in Friesland.
9. *T. cordatum* Palmgren: prefers sandy soil, but has also been found elsewhere.
10. *T. croceiflorum* Dahlstedt: common.
11. *T. cyanolepis* Dahlstedt: rare.
12. *T. dahlstedtii* Lindberg f.: mostly on sand and rather common.
13. *T. duplidens* Lindberg f.: common in the dunes along the seashore, less common on pleistocene sand in the northern and central parts.
14. *T. duplidentifrons* Dahlstedt: common in the north-western half of the country and rare in the south-eastern part; mostly on sandy soil; a var. *brachyglossa* is described.
15. *T. lucidum* Dahlstedt: common, especially on clayish soil; in brackish localities it has been found with *Alopecurus bulbosus*, *Cochlearia officinalis* and *Ranunculus sardous*. Plants resembling *T. fulgidum* Haglund are included here; I regard them as a habitat form.
16. *T. tenebricans* Dahlstedt: in acid and humid pastures, disappearing as a result of agronomic development; it is accompanied in the peat-bog districts by *Hierochloa odorata*, *Viola palustris* and *Carices*, sometimes by *Fritillaria meleagris* or *Sanguisorba officinalis*. It occurs together with other interesting *Taraxaca*: *T. austrinum*,

T. frisicum (ined.), *T. hollandicum* and *T. limnanthes* (all belonging to the *Palustria*), *T. nordstedtii* (*Spectabilia*) and also with other *Vulgaria*.

T. tenebricans seems to be restricted in the Netherlands to a small area (map 3).

LITERATUUR

1. Christiansen, M. P., 1936. Dansk Botan. Ark. 9.2.
2. Christiansen, M. P., 1943. The Botany of Iceland 3.
3. Dahlstedt, H., 1933. Ber. Schweiz. Bot. G. 42.
4. Druce, D., 1920–1931. Reports Bot. Soc. and Exch. Cl. Brit. Isl.
5. Haglund, G. E., 1934 Botan. Notiser.
6. Haglund, G. E., 1936. Botan. Notiser.
7. Haglund, G. E., 1947. Svensk Botan. T. 41.
8. Hylander, N., 1941. Förteckn. Skand. Växter.
9. Lid, J., 1952. Norsk Flora.
10. Lindman, C. A. M., 1926. Svensk Fanerogam Flora.
11. Marklund, G. 1938. Acta Botan. Fennica 23.
12. Marklund, G., 1940. Acta Botan. Fennica 26.
13. Raunkiaer, C., 1934. Dansk Exk. Flora.
14. Saarsoo, B., 1947. Svensk Botan. T. 41.
15. Saarsoo, B., 1949. Soc. Litt. Eston. in Sverige.
16. Soest, J. L. van, 1942. Nederl. Kruidk. Arch. 52.
17. Soest, J. L. van, 1951. Agronom. Lusit. 13.1.
18. Soest, J. L. van, 1954. Collect. Botan. 4.
19. Soest, J. L. van, 1954. Vegetatio 5 & 6.

ACTA BOTANICA NEERLANDICA Vol. 4 (1), 1955

UEBER DIE GATTUNGEN DELITSCHIA AUERSW., TRICHODELITSCHIA MUNK UND CAINIA NOV. GEN.

VON

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(Eingegangen am 30. November 1954)

Die Gattung *Delitschia* wurde von Auerswald (1866) mit der Typusart *Delitschia didyma* aufgestellt (vgl. z.B. Cain, 1934). Bei dieser wie den meisten später zur Gattung gestellten Arten handelt es sich um Mistbewohner. Früher (z.B. bei Winter, 1887) wurde *Delitschia* zusammen mit andern coprophilen Pyrenomyceten in der Familie der *Sordariaceae* zusammengefasst, deren Hauptmerkmal neben ihrer Wachstumsweise vor allem die dunkel gefärbten, mit Schleimhüllen oder hyalinen Anhängseln versehenen Sporen waren. Die betreffenden Gattungen wie *Sordaria* Ces. et de Not., *Delitschia* Auersw., *Sporormia* de Not. und *Hypocopra* Fr. unterschieden sich in der Zellenzahl der Sporen und im Stroma.

Als erster hat von Höhnel (1920) erkannt, dass diese Pilzgruppe heterogen ist. Er erklärte *Sporormia* de Not. als mit *Leptosphaeria* Ces. et de Not. verwandt, während er *Delitschia* Auersw. mit *Phorcys* Niessl vereinigen wollte, ohne sich aber weiter über ihre Stellung zu äussern. Petrak (1924) war mit dieser Lösung nicht einverstanden. Er beschreibt vor allem die grossen Unterschiede, die sich im Sporenbau der beiden ergeben, dann macht er aber auch darauf aufmerksam, dass *Delitschia* gegenüber *Phorcys* die Priorität geniessen würde.

Später hat Cain (1934) in seiner ausgezeichneten Monographie die Gattungen nach dem Bau der Ascusmembran, vor allem der Ascusspitze unterschieden. Er fand nämlich bei den typischen Vertretern der Gattungen *Delitschia* Auersw., *Sporormia* de Not. und *Pleophragmia* Fuck. eine zwar leicht verschleimende, aber deutlich doppelte Ascusmembran. Dabei bricht bei der Reife der obere Teil der nicht dehnbaren, aüsseren Membran als fingerhutförmige Portion auf, sodass sich die dehnbare, innere Membran in die Länge strecken kann. Diese Gattungen gehören daher zu den Bitunicatae im Sinne von Luttrell (1951).

Dagegen besitzen die Asci bei den Gattungen *Coniochaeta* Mass., *Sordaria* Ces. et de Not., *Bombardia* sensu Cain (= *Lasiosordaria* Chen.) eine einfache Membran; sie strecken sich bei der Reife und sind im Apex durchbohrt. Nach unserer heutigen Auffassung gehören diese Gattungen zu den Unitunicatae. Zum gleichen Resultat kam in-

zwischen auch MOREAU (1953), der mehrere Arten der Gattung *Sordaria* (im Sinne von CAIN), sowie andere coprophile Pyrenomyceten einer eingehenden Untersuchung unterzog.

MUNK (1953) dagegen stellte *Delitschia* — ohne Untersuchung der Typusart — zu den Ascohymeniales (= Unitunicatae) und begründete für *Delitschia bisporula* (Crouan) Hansen, bei der er eine doppelte Ascusmembran beobachten konnte, eine neue Gattung *Trichodelitschia*, welche daher — allein nach seiner Gattungsdiagnose beurteilt — wieder mit *Delitschia* vereinigt werden müsste.

Nun wollte aber bereits CAIN (1934) *Delitschia bisporula* von der Gattung ausschliessen, da sie von den typischen *Delitschia*arten in mehrfacher Hinsicht abweicht. Einmal sind die Gehaüse mit spitzen Borstenhaaren (Setae) besetzt, während diejenigen der typischen *Delitschia*arten kahl sind oder doch nur flexible Hyphenhaare tragen. Ferner besitzen die Ascosporen von *Delitschia bisporula* an jedem Ende einen farblosen Höcker (Keimporus); die Sporen der typischen *Delitschia*arten besitzen demgegenüber Keimspalten, welche jede Zelle seitlich in ihrer ganzen Länge durchfurchen (vgl. auch MOREAU, 1953, der die Keimporen von *Delitschia bisporula* ausführlich beschrieb, während diese von MUNK, 1953 nicht erwähnt wurden). Die Gattungen *Delitschia* Auersw. und *Trichodelitschia* Munk können demnach nebeneinander bestehen bleiben und sind durch die angegebenen Merkmale zu unterscheiden.

Es war uns daran gelegen, selber nochmals Einblick in die geschilderte Situation zu nehmen. So haben wir einige *Delitschia*arten, darunter in erster Linie den Gattungstypus nochmals untersucht; die Erkenntnisse van CAIN (1934) und MOREAU (1953) können wir darnach vollauf bestätigen. Wir wollten *Delitschia* auch mit einigen, wenigstens der Diagnose nach ähnlichen Gattungen vergleichen und haben uns deshalb bemüht, Originale der Typusart von *Phorcys* Niessl zu beschaffen. Wie uns aber aus der botanischen Staatssammlung in München (Prof. Dr. K. SUESSENGUTH) mitgeteilt wurde, ist *Phorcys betulae* Niessl im Niessl'schen Herbar nicht vorhanden und muss als verloren gelten. Auch VON HÖHNEL (1920) und PETRAK (1924) konnten diesen Pilz nicht untersuchen, sondern basierten ihre Nachprüfungen auf *Phorcys bufonia* (Berk. et Br.) Schröt., welche Art aber Typus der Gattung *Massariella* Speg. ist. Da *Phorcys betulae* seit NIESSL's Beschreibung nicht mehr gefunden wurde und kein Material des Pilzes existiert, lässt sich die Gattung *Phorcys* nicht mehr aufklären und ist zu streichen.

Die Untersuchung von *Massariella bufonia* (Berk. et Br.) Speg. bestätigte die Auffassung verschiedener Autoren, nach denen diese Gattung zu den *Pseudophaeriales* zu stellen ist (z.B. MUNK, 1953). Die Sporen besitzen im Gegensatz zu *Delitschia* oder *Trichodelitschia*, weder Keimspalten noch Keimporen, ferner bestehen deutliche Unterschiede im Fruchtkörperbau. *Massariella* scheint uns jedenfalls nicht näher mit *Delitschia* verwandt zu sein. Auch die Gattung *Ceriosporopsis* Linder gehört nach den Untersuchungen von WILSON (1954) zu den *Pseudosphaeriales* und scheint mit *Massariella* nahe verwandt zu sein, sich aber

durch die Sporenanhängsel und die Wachstumsweise (auf in Seewasser liegendem Holz) zu unterscheiden.

Auf Grund unserer Untersuchungen möchten wir *Delitschia* Auersw., *Trichodelitschia* Munk, *Sporormia* de Not. und *Pleophragmia* Fuck. provisorisch in der Familie der *Sporormiaceae* zusammenfassen. Die Vertreter dieser Familie der *Pseudosphaeriales* würden sich vor allem durch die opak dunkel gefärbten, leicht in ihre Teilzellen zerfallenden und mit Keimspalten oder Keimporen versehenen Sporen, sowie durch die coprophile Wachstumsweise auszeichnen.

Ein eigenartiger und ganz anders gebauter Pilz ist dagegen die auf Gramineen und Cyperaceen wachsende *Delitschia graminis* Niessl. Diese Art soll vorerst an Hand selbst gesammelter, von verschiedenen Wirten und Standorten stammenden Exemplaren [1]) beschrieben werden (vgl. auch PETRAK, 1931):

Ueber den zerstreut dem Substrat eingesenkt wachsenden Fruchtkörpern ist die etwas pustelförmig aufgetriebene Epidermis durch dunkel gefärbte Hyphen des Pilzes mehr oder weniger braunschwarz gefärbt. Die kugeligen Fruchtkörper nehmen fast die ganze Blattdicke ein, erreichen einen Durchmesser von 300–500 μ und brechen mit einer kegelförmigen, zuweilen etwas schiefen, oft verlängerten und dann schwach vorragenden, 90–180 μ hohen und 100–150 μ breiten Mündung hervor. Die Wand der Gehäuse ist 20–30 μ dick und besteht aus zahlreichen Lagen von flach niedergedrückten, oft undeutlichen, oft hyphigen, aussen hellbraunen, 4–8 μ grossen, innen zarten, hyalinen, in Schnitten fast faserig erscheinenden Zellen (vgl. Abbildung 1). Die Mündung ist von einem unten weiten, nach oben verengten, reich mit Periphysen besetzten Kanal durchbohrt.

Die meist zahlreichen, parallel stehenden Asci sind zylinderisch-keulig oder oft etwas bauchig, oben gestutzt, unten kurz gestielt, 170–270 μ lang, 20–40 μ breit und enthalten acht Sporen. Sie besitzen eine einfache, zarte, aber vor allem oben stark verdickte Membran. In der Spitze befindet sich ein ziemlich kompliziert gebauter Apikalapparat (Abbildung 2 a, b,). Das nach oben verengerte Ascusvolumen bildet zuerst einen engen Kanal, der sich unter einer horizontalen, flachen oder etwas konvexen, ca. 2 μ dicken Platte zu einem Gewölbe erweitert, das ein körniges Plasma enthält. Ueber der Platte liegt ein helmförmiger, unten flacher, 6–8 μ breiter, horizontal geschichteter, stark lichtbrechender Körper, der kanalartig von einem vertikalen Gebilde durchstossen wird und sich mit Jod-Jod-Kali blau färbt, also Glucosane enthält. Das vertikale Gebilde setzt sich nach oben fort, erweitert sich etwas und bildet in der Mitte der oft eingesunkenen Spitze eine kleine Vorwölbung.

Die 28–40 $\times$ 12–16 μ grossen, zweizelligen Ascosporen sind von

[1] auf *Poa alpina* L. — Helv. Kt. Graubünden, Filisur-Muchetta, Plan Grond, 3.8.1949, leg. E. MÜLLER; auf *Sesleria calcaria* Opitz — Helv. Kt. Graubünden, Samnaun, 17.8.1951, leg. E. MÜLLER; *Sesleria calcaria* Frankreich, Alpes maritimes, Tende, 6.8.1953 leg. E. MÜLLER und K. H. RICHLE; *Sesleria calcaria* (sub. *Sesleria varia* Jaqu.) Wettst. Oesterreich, Niederdonau, Pfaffstäaten bei Baden, VI. 1940 leg. F. PETRAK, Mycotheca generalis Nr. 622.

einer breiten Schleimhülle umgeben. In der Seitenansicht sind sie länglich-ellipsoidisch oder fast spindelförmig und zeigen bei der sich in der Mitte befindlichen Querwand eine deutliche Einschnürung und in jeder Zelle drei bis vier helle Längsrippen. An jedem Ende befindet sich ein Keimporus, der durch ein farbloses, flaches, knopfförmiges Gebilde nach aussen abgeschlossen ist. Von oben gesehen zeigen die Ascosporen ein regelmässig achteckiges Querschnittsbild; die in der Seitenansicht festgestellten Rippen entsprechen den Ecken des Achteckes (vgl. Abbildung 2 e). Die Ascosporenwand ist verhältnismässig dick, dabei ist das Exospor farblos und stark lichtbrechend, während die Spore durch das dunkelbraun gefärbte Endospor bei völliger Reife fast opak schwarz erscheint. Die ziemlich zahlreichen Paraphysen sind breit fädig und durch Querwände unterteilt.

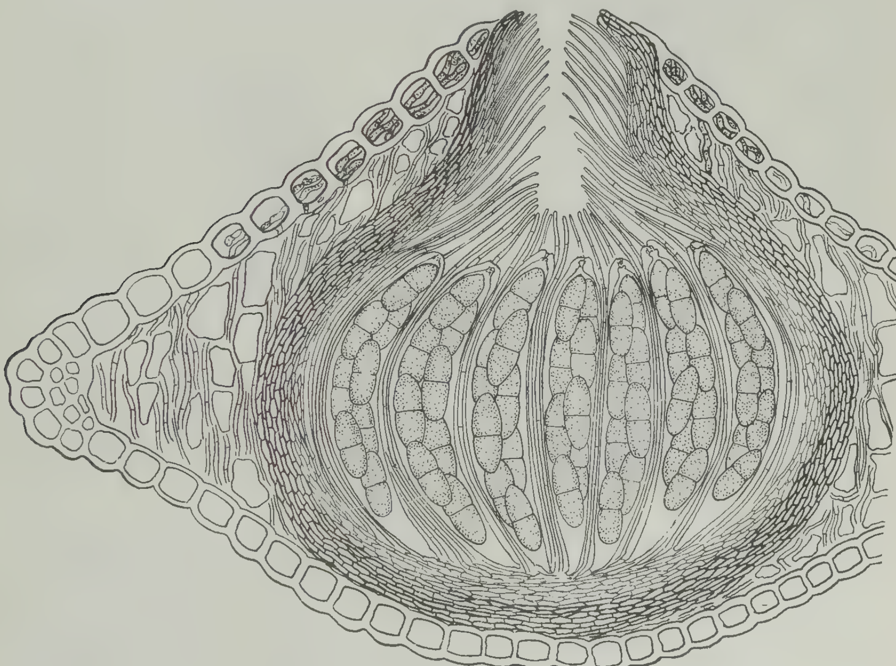

Abbildung 1. Schnitt durch einen Fruchtkörper von *Cainia graminis*. Vergr. 250 mal.

Dieser Pilz kann in keiner bestehenden Gattung untergebracht werden; er stellt vielmehr den Typus einer neuen dar, die wir zu Ehren von Herrn Prof. Dr. R. F. Cain, Toronto Kanada, *Cainia* nennen möchten.

Cainia nov. gen.

Typus: *Cainia graminis* (Niessl) comb. nov.

Perithecia solitaria, immersa, globosa; ostiolo papilliformo periphysato; pariete peritheciorum micro-parenchymatico, e stratis pluribus cellularum valde com-

pressarum composito. Asci cylindraceo-clavati, unitunicati, 8-spori; sporae, didymae, ellipsoideae, transverse octogonae, episporis hyalinibus et endosporis brunneis vel nigris, mox mucosae, partibus extremis poris germ. praeditae. Paraphyses numerosae, hyalinae, fibrosae, cellulatae.

Saprophyten mit dem Substrat eingesenkten, einzel stehenden, kugeligen, mit einer von einem Kanal durchbohrten und innen mit Periphysen bekleideten Mündung hervorbrechenden Perithecien. Gehäusewand braun, mikroparenchymatisch aus zahlreichen Lagen von flachen Zellen aufgebaut. Asci parallel stehend, zylindrisch-keulig, 8-sporig, unitunicat, mit Apikalapparat. Sporen zweizellig, länglich ellipsoidisch, im Querschnitt achteckig, gross, mit farblosem Exospor und braunem oder opak schwarzbraunem Endospor, farbloser Schleimhülle und beidends einem Keimporus versehen. Paraphysen zahlreich, farblos, fädig und etwas zellig.

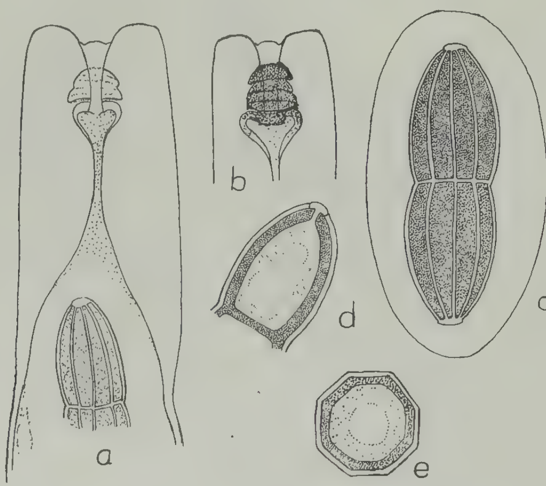

Abbildung 2. *Cainia graminis* a) Ascusspitze mit Apikalapparat (ungefärbt), b) Ascusspitze (gefärbt), Vergr. 750 mal. c) Ascospore, Oberflächenansicht, d) Längsschnitt durch eine Zelle, e) Querschnittsbild. Vergr. 1000 mal.

Die oben beschriebene Typusart hat nun *Cainia graminis* (Niessl) Müller et v. Arx zu heissen:

Cainia graminis (Niessl.) comb. nov.

Synonyme: *Delitschia graminis* Niessl — Verh. naturf. Ver. Brünn, *14*, 48, (1871) *Phorcys eriophori* Feltg. — Pilzfl. Luxemb. Nachtr. *3*, 162, (1903) *Massariella eriophori* Sacc. — Syll. Fung. *17*, 683, (1905) *Phorcys lovereana* Rehm — Ann. Myc. *4*, 269, (1906) *Massariella lovereana* Sacc. et Trott. — Syll. fung. *22*, 179, (1914).
Matrix: auf Gramineen und Cyperaceen (Mitteleuropa).

Die Gattung *Cainia* gehört zu den *Sphaeriales* in die Familie der *Xylariaceae* sensu Von Arx und Müller (1954). Wollte man im Sinne von Munk (1953) die beiden Familien der *Xylariaceae* und *Lasiosphaeriaceae* anerkennen, dann würde dieser Pilz eine Zwischenform

darstellen, die nach gewissen Merkmalen in die erste, nach andern in die zweite Familie passen würde. Das fehlende Stroma, die Schleimhülle und die Keimporen der Sporen würden seine Einreihung bei den *Lasiosphaeriaceae* rechtfertigen; nach dem Bau der Ascusspitze und der Gehäusewand dagegen würde er zu den *Xylariaceae* im Sinne von MUNK (1953) gehören.

Cainia nimmt innerhalb der *Xylariaceae* eine ziemlich isolierte Stellung ein. Am nächsten scheint die Gattung noch mit *Ceriophora* v. Höhn., *Ceriospora* Niessl und *Zygospermella* Cain verwandt zu sein.

Die Typusart von *Zygospermella* Cain (= *Zygospermum* Cain non Thwaites) konnten wir zwar nicht untersuchen; die Gattung ist aber nach der von CAIN (1935) entworfenen Diagnose von *Cainia* verschieden durch ihr coprophiles Wachstum, durch die hervorbrechenden, behaarten Perithecien und durch die Ascosporen, die bei der Querwand tief eingeschnürt sind und beidends einen kleinen Keimporus und ein langes Anhängsel, aber keine Schleimhülle besitzen. Auch fehlt jegliche Oberflächenstruktur. Die Asci sollen eine einfache Membran und im Apex eine kleine "Perforation" (Oeffnung) besitzen.

Die monotypische Gattung *Ceriophora* wurde von VON HÖHNEL (1919) für *Sphaeria palustris* Berk. et Br. begründet und die Art wurde mit einer guten Diagnose versehen. Als *Didymosphaeria palustris* (Berk. et Br.) Sacc. wurde der Pilz auch von PETRAK (1940) ausführlich beschrieben. Nach den von uns untersuchten Exemplaren unterscheidet sich *Ceriophora* von *Cainia* nur in den Asci und Sporen. Diese besitzen wohl eine feine Längsstreifung, sind aber im Querschnitt rundlich. Keimporen konnten wir keine beobachten und die Schleimhülle ist beidends anhängselartig in einen langen, meist kegelförmigen Fortsatz ausgezogen (vgl. Abb. 3). Der Apikalapparat der Asci besteht aus einem kleinen Apikalkissen und einer darunter liegenden, flachen, 3–4 μ breiten, in der Mitte perforierten Apikalplatte, die sich mit Jod blau färbt.

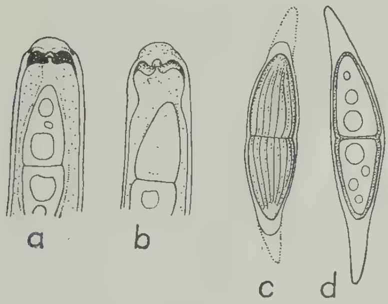

Abbildung 3. *Ceriophora palustris* a) Ascusspitze gefärbt, b) Auscusspitze ungefärbt, c) Ascospore, Oberflächenansicht (Milchsäurepräparat), d) Ascospore, optisches Bild. Vergr. 1000 mal.

Eine ganz ähnliche Struktur zeigt die Ascusspitze von *Ceriospora* Niessl (Typus *Ceriospora Dubyi* Niessl), nur ist dort das Apikalkissen dünner und die ebenfalls in der Mitte durchbohrte Platte ist rund um diese Perforation nach unten verdickt und liegt oben direkt dem Kissen an (vgl. Abb. 4). Die Ascosporen dieser Art besitzen keine Schleimhülle, ihre Wand ist aber an den verjüngten Enden in ein pfriemenför-

miges Anhängsel ausgezogen. Ferner bleiben sie lange hyalin und einzellig, erhalten aber reif eine Querwand und eine gelbliche oder hellbraune Farbe.

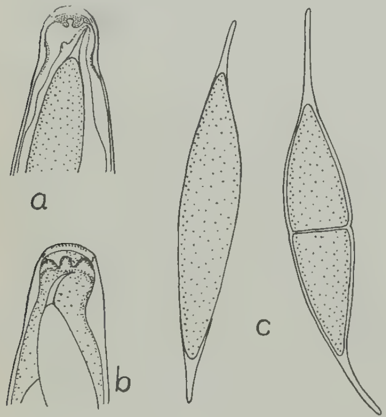

Abbildung 4. *Ceriospora Dubyi* a) Ascusspitze gefärbt, b) Ascusspitze ungefärbt, c) Ascosporen. Vergr. 1000 mal.

Ceriospora wurde von VON HÖHNEL (1918) bei den *Physosporellaceae* (= *Hyponectriaceae* sensu PETRAK, 1923) untergebracht; er erkannte also den sphaerialen Bau des Pilzes. Dagegen stellte MUNK (1953) die Gattung unbegreiflicherweise zu den *Pseudosphaeriales* neben *Pyreniella* Theiss. (= *Botryosphæria* Ces. et de Not.), von der sie sich nur durch die mit Anhängseln versehenen Sporen unterscheiden sollte! Diese Einteilung ist natürlich völlig unbegründet und *Ceriospora* lässt sich weder im Bau der Gehäuse noch dem der Fruchtschicht, der Asci oder der Sporen mit *Pyreniella* vergleichen.

Apikalstrukturen wie wir sie bei *Cainia*, *Ceriophora* und *Ceriospora* fanden, sind vor allem bei den höheren *Xylariaceae* (sensu VON ARX und MÜLLER, 1954), sowie bei den inoperculaten Discomyceten weit verbreitet (CHADEFAUD, 1940), fehlen dagegen, soweit bekannt, u.a. bei den *Nectriaceae* und den *Polystigmataceae*, sowie bei den primitiveren Vertretern der *Xylariaceae*. Aus diesem Grunde wurden diese von MOREAU (1953) wie auch von MUNK (1953) in eine eigene Familie der *Sordariaceae* bzw. *Lasiosphaeriaceae* gestellt.

Vergleicht man nun die Apikalstrukturen von *Cainia graminis* z.B. mit denen von *Xylaria polymorpha* (Pers.) Grev. (Abb. 5.), dann sieht man, dass diese in ihrem Bau voneinander etwas abweichen, besonders fehlt bei *Xylaria* die bei *Cainia* das innere Gewölbe bildende, konvexe oder halbkugelige Platte. Dagegen fanden wir bei allen untersuchten Formen das endständige Kissen und die in der Mitte durchstossene Apikalplatte. Diese hat bei *Cainia* und *Xylaria* die Form eines Zapfens und ist horizontal geschichtet, wie dies MOREAU (1953) auch bei *Hypocopra* fand. Dagegen war diese Platte bei der *Diatrypaceae* *Quaternaria Personii* Tul. [= *Quaternaria quaternata* (Pers.) Schroet.] einfach und bei dieser Art stimmte der Apikalapparat weitgehend mit dem von *Ceriophora* oder *Ceriospora* überein. Anderseits fanden wir bei der auf einer tieferen Stufe stehenden *Lasiosphaeria ovina* (Pers.) Ces.

et de Not., wie auch bei *Neurospora* Shear et Dodge oder *Gelasinospora* Dowd. keine differenzierten Apikalstrukturen.

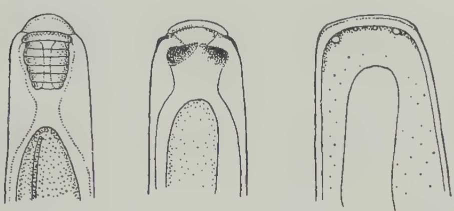

Abbildung 5. Ascusspitze von a) *Xylaria polymorpha* b) *Quaternaria Personii* (gefärbt) c) *Lasiosphaeria ovina* (lässt sich nicht färben). Alle Vergr. 2000 mal.

ZITIERTE LITERATUR

Arx, J. A. von und E. Müller, 1954. Die Gattungen der amerosporen Pyrenomyceten. Beitr. Krypt. fl. der Schweiz, 11 : 1, 439 S.

Auerswald, B. ,1866. Delitschia nov. gen. Hedwigia, 5 : 49.

Cain, R. F., 1934. Studies on coprophilous Sphaeriales in Ontario. Univ. of Toronto Studies, Biol. Ser. 38 : 126 S.

Cain, R. F., 1935. Mycologia 27 : 227.

Höhnel, F. von, 1918. Ann. Mycol. 16 : 92.

Höhnel, F. von, 1919. Sitzber. K. Ak. Wissensch. Wien. math.-naturw. Kl., 1. Abt., 128 : 585.

Höhnel, F. von, 1920. l.c. 129 : 157–162.

Luttrell, E. S., 1951. Taxonomy of the Pyrenomycetes. Univ. Missouri Studies, 24 : 3, 120 S.

Moreau, Cl., 1953. Les genres *Sordaria* et *Pleurage*. 330 S. P. Lechevalier, Paris.

Munk, A., 1953. The System of the Pyrenomycetes. Dansk. Bot. Arkiv., 15 : 2, 163 S.

Petrak, F., 1923. Ann. Mycol. 21 : 305.

Petrak, F., 1924. l. c. 22 : 139–142.

Petrak, F., 1931. Krypt. Forsch. Bayr. Bot. Ges. *2*, 159.

Petrak, F., 1940. Ann. Mycol. 38 : 350.

Wilson, I. M., 1954. Transact. Brit. Myc. Soc. 37 : 272–285.

Winter, G., 1887. Die Pilze in Rabenhorst: Kryptogamenflora, *I*[2].

ACTA BOTANICA NEERLANDICA, Vol. 4 (1), 1955

UEBER DIE GATTUNGEN SELINIA KARST. UND SELINIELLA NOV. GEN. UND IHRE PHYLOGENETISCHE BEDEUTUNG

VON

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(Eingegangen am 30. November 1954)

In unserer Arbeit über die amerosporen Gattungen der Pyrenomyceten (Von Arx und Müller, 1954) konnten wir nichts über die systematische Stellung der Gattung *Selinia* Karst. mitteilen, da wir damals von der einzigen Art *Selinia pulchra* (Wint.) Karst. kein Material untersuchen konnten und die in der Literatur vorhandenen Beschreibungen für eine Beurteilung des Pilzes nicht genügten. Inzwischen gelang es uns, einige Stromata von *Selinia pulchra* nachzuprüfen, ferner fanden wir auf einer Exkursion in die Westalpen [1] einen bisher unbekannten, mit *Selinia* nahe verwandten Ascomyceten. Diesen stellen wir in eine eigene Gattung *Seliniella*, die sich von *Selinia* durch die nicht einem Stroma eingesenkten, sondern einzeln einem Hypostroma aufgewachsenen und oben dunkel gefärbten Perithecien unterscheidet. Ferner besitzen die Fruchtgehäuse von *Seliniella* als Mündung höchstens einen punktförmigen, kleinen Porus, während sich diejenigen von *Selinia* im kegelförmigen Scheitel mit einem reich mit Periphysen besetzten Kanal öffnen. Die beiden Gattungen sollen vorerst etwas ausführlicher besprochen werden.

1. **Selinia Karst.**

Symb. myc. fenn. *3*, 57 (1876)

Typonyme: *Hypocreopsis* Winter — Hedwigia *14*, 26 (1875) non Karsten (1873) *Winteria* Sacc. — Michelia *1*, 281 (1878) non Rehm (1875) *Seliniana* O. Kuntze — Rev. Gen. Plant. *2*, 869, 982 (1891).

Die grossen, dem Substrat (Fäkalien) eingesenkten, oft vorragenden Stromata sind unregelmässig knollen- oder polsterförmig, aussen rostrot oder bräunlich, innen weisslich, fleischig-knorpelig und bestehen aus einem Gewebe von rundlich- eckigen, zarten, mittelgrossen Zellen. Die einzeln oder zu wenigen dem Stroma eingesenkten Perithecien sind kugelig und brechen mit einer kegelförmigen, von einem mit

[1] Dem Präsidenten des Schweizerischen Schulrates, Herrn Prof. Dr. H. Pallmann danken wir herzlich für einen Beitrag an die Exkursionskosten aus dem Albert-Barth-Fonds.

zahlreichen Periphysen besetzten Kanal durchbohrten Mündung hervor. Die fleischige Gehäusewand besteht aus zahlreichen Lagen von flachen, hyalinen Zellen. Die keuligen Asci besitzen eine einfache Membran und enthalten meist acht einzellige, hyaline Sporen. Diese besitzen ein dickes Epispor und sind von einer deutlichen Schleimhülle umgeben.

Die Gattungsynonyme sind alle drei obligat. *Seliniana* O. Kuntze ist nicht als definitiver Name vorgeschlagen worden und deshalb für die Nomenklatur belanglos.

Abbildung 1. Schnitt durch ein Stroma von *Selinia pulchra* mit einem Perithecium. Vergr. ca. 40 mal.

1. **Selinia pulchra** (Wint.) Karst.

Synonyme: vide Winter, 1887.
Matrix: auf altem Mist von Kühen, Schafen und Pferden (Deutschland, Holland, Dänemark).

Die dem Substrat eingesenkten, mit dem Scheitel oft etwas vorragenden, zerstreut oder in kleinen Herden stehenden Stromata sind unregelmässig polster- oder knollenförmig, oben oft flach, oft breit kegelig, $1\frac{1}{2}$-3 mm gross oder durch Zusammenfliessen noch grösser, aussen rostrot und oft etwas filzig. Innen sind sie fleischig, hyalin oder gelblich und bestehen aus einem Gewebe von rundlichen oder unregelmässig eckigen, oft etwas länglichen, 10-20 μ grossen, dünnwandigen Zellen und sind hie und da von Resten des sonst resorbierten Substrates durchsetzt.

Die einzeln oder zu wenigen dem Stroma tief eingesenkten Perithecien sind kugelig, 450-650 μ gross und brechen mit einer kegelförmigen, oft etwas vorragenden, 200–300 μ hohen und ebenso breiten Mündung nach aussen. Diese ist von einem oben sich verengenden, von sehr zahlreichen, fadenförmigen, hyalinen, ca. 2 μ dicken Periphysen besetzten Kanal durchbohrt. Die 30–50 μ dicke Gehäusewand ist

fleischig und besteht aus zahlreichen Lagen von konzentrisch abgeflachten, ziemlich dünnwandigen, hyalinen oder gelblichen Zellen.

Die parallel stehenden Asci sind keulig, in der Mitte oft bauchig erweitert, 160–220 × 40–60 μ gross und besitzen eine einfache, zarte, leicht verschleimende, ca. 2 μ dicke Membran. In der anfänglich etwas verjüngten und dann breit abgerundeten Spitze konnten keine Apikalstrukturen beobachtet werden. Die zu acht oder weniger im Ascus liegenden Sporen sind länglich-ellipsoidisch, beidends verjüngt und dann abgerundet, 48–64 × 20–26 μ gross. Sie besitzen ein 2–3 μ dickes, hyalines, stark lichtbrechendes, aus wenigstens zwei Schichten (Exospor und Endospor) bestehendes Epispor und enthalten ein gelbliches, fein granulöses Plasma. Keimporen oder Keimspalten konnten nicht beobachtet werden, dagegen scheinen die Sporen eine unregelmässige und undeutliche Schleimhülle zu besitzen.

Nach den Angaben von WINTER (1887) sollen die Stromata aussen von Hyphen besetzt sein, die einen Filz bilden und an denen einzellige Sporen abgeschnürt werden. Die von uns untersuchten Stromata waren alt und teilweise schlecht entwickelt, und wir konnten diese erwähnte Konidienform nicht finden.

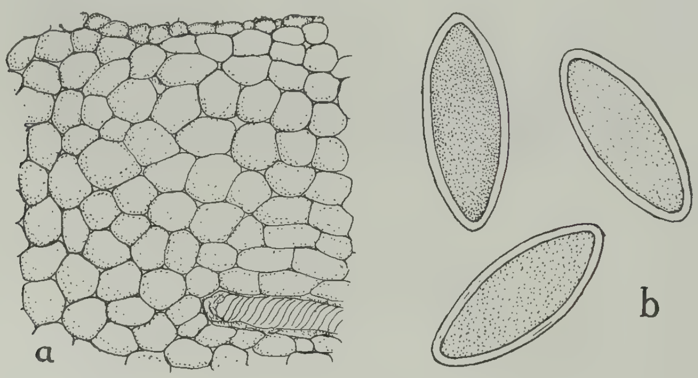

Abbildung 2. *Selinia pulchra* a) Stromapartie von farblosem, parenchymatischem Gewebe, mit Substrateinschlüssen, Vergr. 500 mal. b) Ascosporen, Vergr. 500 mal.

2. **Seliniella nov. gen.**

Fimicolae; perithecia semiimmersa, nigra, globosa vel irregulariter ellipsoidea, rarissime poris minutis aperta, saepe non ostiolata; paries perithecii ad apicem et ad latera fusco, e stratis cellularum pluribus, plus minusve minorbus, elongatis formato, basi hypostromati; hypostroma carnosa, e cellulis hyalinis vel subflavis, angulatis-rotundatis composita. Asci clavati, membranis simplicibus, octosporae. Sporae ellipsoideae, continuae, episporis primum hyalinsi, demum coloratis, cum mucis gelatinosis. Paraphyses numerosae, fibrosae, hyalinae.

Mistbewohner mit ungefähr zur Hälfte dem Substrat eingesenkten, dunkeln, kugelig-knollenförmigen, sklerotienartigen Fruchtkörpern. Die Gehäusewand ist oben und seitlich braun und besteht aus mehreren Lagen von ziemlich kleinen, flachgedrückten, rundlich-eckigen oder

gestreckten Zellen. Unten ist sie hypostromatisch verdickt; sie ist dann sklerotial-fleischig und besteht aus hyalinen oder gelblichen, rundlich-eckigen, zarten, mittelgrossen Zellen. Eine Mündung fehlt oder besteht aus einem scheitelständigen, kleinen, rundlichen Porus. Die Asci sind keulig und besitzen eine einfache, im Scheitel nicht verdickte Membran. Sie sind von zahlreichen fadenförmigen Paraphysen umgeben und enthalten acht ellipsoidische, einzellige Sporen. Diese sind von einem granulösen Plasma erfüllt, besitzen ein sehr lange hyalin bleibendes, sich im Alter aber manchmal intensiv färbendes und dann fein gefeldertes Epispor und sind von einer scharf begrenzten Schleimhülle umgeben.

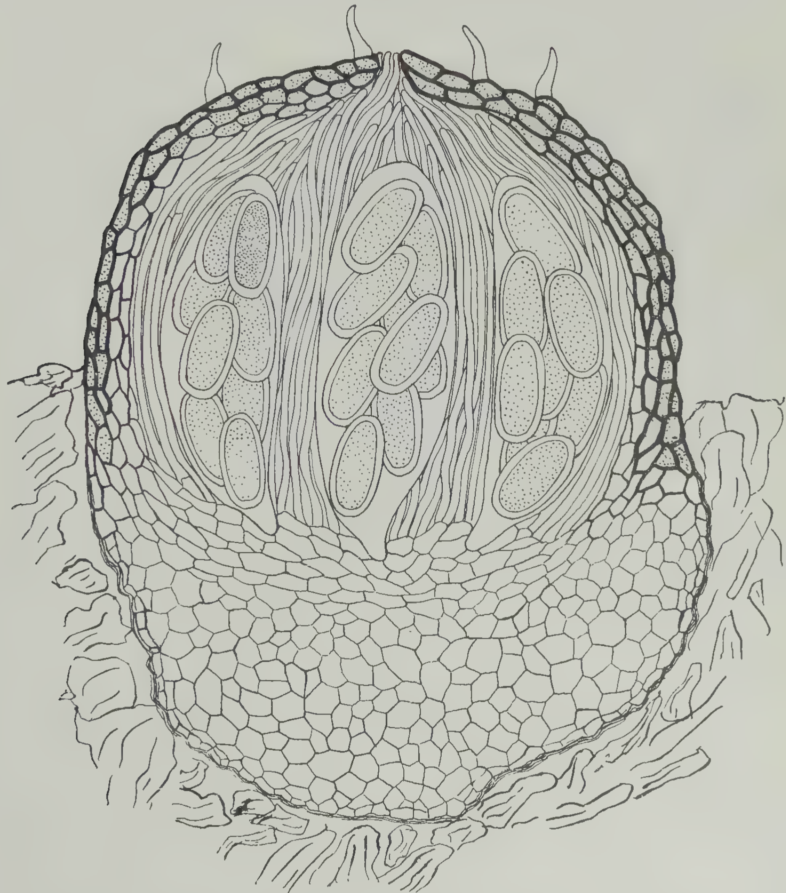

Abbildung 3. Schnitt durch ein Stroma von *Seliniella macrospora*. Vergr. 250 mal.

1. **Seliniella macrospora** nov. spec.

Matrix: auf altem Kuhmist (Hautes Alpes, Frankreich).

Perithecia semiimmersa, globosa vel ellipsoidea, brunnea, 300–600 μ diam., rarissime poris minutis aperta, saepe non ostiolata; paries perithecii ad apicem

et ad latera 22–40 μ crasso, e stratis cellulorum pluribus, brunneis formato, basi hypostromati; hypostroma carnosa, e cellulis irregulariter angulatis vel rotundatis, 8–17 μ diam. composita. Asci clavati-cylindracei, 160–210 × 40–65 μ, membranis simplicibus, octo sporae. Sporae ellipsoideae, continuae, 42–55 × 28–36 μ, primum hyalinae demum coloratae (violaceae vel purpureae), cum episporis 2,5–3,5 μ crassis, duplicibus, e cum mucis gelatinosis. Paraphyses 2–3 μ crassae, hyalinae vel subflavae, fibrosae.

Hab. in fimo vaccino — Gallia, Bregantia, Val Queyras, Aiguilles, Eygliers, 10.6.1954, leg. E. Müller *et* K. H. Richle.

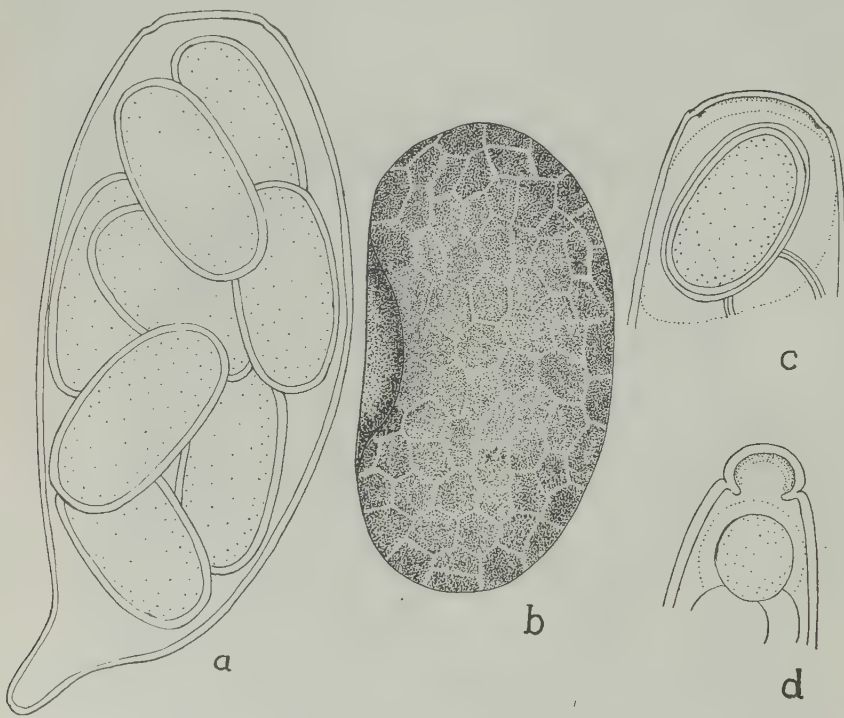

Abbildung 4. *Seliniella macrospora* a) Ascus, Vergr. 500 mal, b) überreife Ascospore, Vergr. 1000 mal, c) Spitze eines reifen Ascus, d) Spitze eines jungen Ascus, Vergr. 500 mal.

Die ungefähr zur Hälf.e dem Substrat eingesenkten, aussen schwarzbraunen Fruchtkörper sind kugelig, knollen- oder paukenförmig und erreichen einen Durchmesser von 300–600 μ. Oben und seitlich ist die Wand des Gehäuses 22–40 μ dick und besteht aus mehreren Lagen von etwas flachgedrückten, ziemlich dickwandigen, braun erscheinenden, von oben gesehen rundlich eckigen oder gestreckten und oft hyphig verschlungenen, 7–13 μ grossen oder 5–8 μ breiten und dann bis 25 μ langen Zellen. Unten geht die Wand in einen 300–500 μ breiten und 150– 280 μ hohen, hypostromatischen Fuss über. Dieser ist fleischig- knorpelig und besteht aus einem Gewebe von zartwandigen, polyedrischen oder rundlich- eckigen, hyalinen,

8–17 μ grossen, am zarten Rande etwas flach gedrückten und kleinern Zellen.

Im flachen oder etwas vorgewölbten Scheitel befindet sich hie und da ein rundlicher Porus, der meist völlig flach ist, seltener etwas papillenförmig vorragt und in den hinein Paraphysen wachsen. In den meisten Fällen scheint aber eine vorgebildete Mündung zu fehlen, der Fruchtkörper öffnet sich vielmehr durch Wegsprengen des Scheitels.

Die zylinderisch-keuligen oder oft bauchig erweiterten, 160–210 × 40–65 μ grossen Asci besitzen eine einfache, 2–3 μ dicke Membran. In der Spitze ist diese nicht verdickt, der flache, deckelförmige Apex ist aber vom übrigen Schlauch durch eine ringförmige Einschnürung etwas abgesetzt.

Die acht zwei- bis dreireihig im Ascus liegenden Sporen sind ellipsoidisch, beidends breit abgerundet, 42–55 μ lang und 28–36 μ breit. Sie besitzen ein 2,5–3,5 μ dickes, zweischichtig aufgebautes Epispor und enthalten ein fein granulöses, hyalines oder schwach gelbliches Plasma. Die Sporen sind hyalin, erhalten aber im Alter hie und da eine weinrote oder violette Farbe und dann erscheint ihre Oberfläche auch durch hyaline Leisten gefeldert. Diese Leisten werden durch das etwas verschrumpfte Epispor gebildet und die alten gefärbten Sporen sind durch Austrocknung meist seitlich etwas schüsselförmig eingesunken (vgl. Abb. 4b). Die netzartig angeordneten, weissen Linien verschwinden unter dem Einfluss von Milchsäure. Hyaline Sporen sind immer von einer breiten und deutlichen Schleimhülle umgeben. Die sehr zahlreichen Paraphysen sind fadenförmig, 2–3 μ dick, unseptiert und hyalin oder im Alter gelblich.

Systematische Stellung und Phylogenie

Wie aus den Beschreibungen und Abbildungen hervorgeht, stimmen *Selinia pulchra* und *Seliniella macrospora* im Bau der Fruchtschicht, besonders der Asci und Sporen fast völlig überein und stehen sich ohne jeden Zweifel sehr nahe. Die beiden Gattungen unterscheiden sich nur in der Form und Grösse der Stromata und in der Ausbildung der Mündungen.

Als unitunicate Pyrenomyceten gehören beide Pilze zu den Sphaeriales, stehen aber innerhalb dieser Reihe auf einer primitiven Stufe und lassen sich in keiner der von Von Arx und Müller (1954) für die amerosporen Gattungen angegebenen Familien zwanglos unterbringen. Die nächsten Beziehungen bestehen noch zu den *Polystigmataceae*; diese unterscheiden sich aber durch ihre Wachstumsweise (meist Parasiten auf Phanerogamen), durch die Ausbildung anders gebauter Stromata (Pseudostromata) mit typischen Perithecien, sowie durch die meist kleinern Ascosporen. Die *Xylariaceae*, deren Vertreter zum Teil auch auf Fäkalien wachsen, unterscheiden sich durch dunkel gefärbte, mit Keimporen oder Keimspalten versehene Ascosporen.

Selinia und *Seliniella* müssen bei den Sphaeriales in einer eigenen Familie untergebracht werden, für die wir den Namen *Seliniaceae* vorschlagen und die sich durch folgende Merkmale auszeichnet:

Coprophile Pilze mit ziemlich grossen, knollen- oder polsterförmigen Fruchtkörpern bzw. Stromata. Diese sind hell, fleischig oder knorpelig, parenchymatisch und bestehen aus zarten, eckig-rundlichen Zellen. Die Mündung der rundlichen Perithecien fehlt, besteht aus einem einfachen Porus oder ist kegelförmig und dann von einem periphysierten Kanal durchbohrt. Die nicht sehr zahlreichen Asci besitzen eine einfache Membran und keine Apikalstrukturen. Die Ascosporen sind gross (50×25 μ), mit einem dicken Epispor versehen ohne Keimporen oder Keimspalten. Wenigstens in der Jugend sind sie farblos und von einer Schleimhülle umgeben.

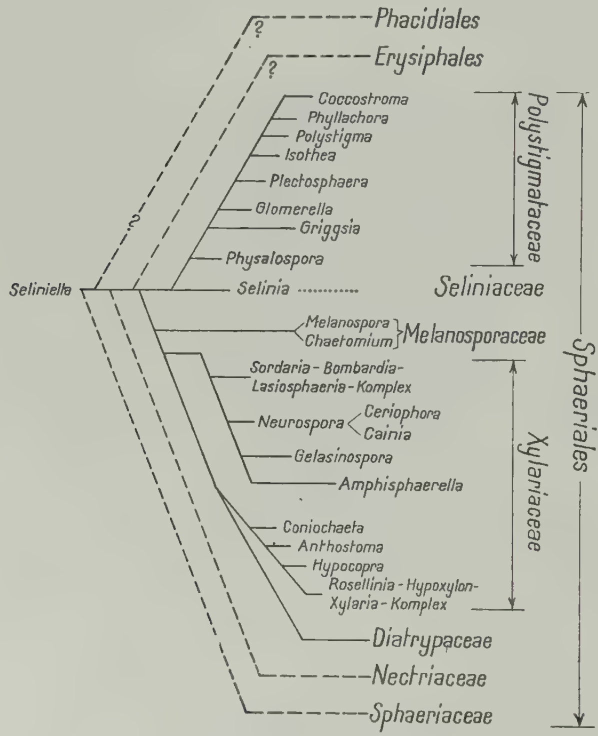

Abbildung 5. Stammtafel der Sphaeriales in schematischer Darstellung.

Unter den uns bekannten Vertretern der Sphaeriales stellen die *Seliniaceae*, besonders *Seliniella macrospora* die primitivsten Formen dar und ihre Stellung entspricht ungefähr der von *Wettsteinina* innerhalb der *Pseudosphaeriales* (vgl. Müller und Von Arx, 1950). Auf folgenden, mit *Wettsteinina* übereinstimmenden Entwicklungs- und Baumerkmalen basieren wir unsere Auffassung:

Die Fruchtkörper sind bei *Seliniella macrospora* in ihrer Form noch nicht fixiert, sie stellen vielmehr knollenförmige, wenig differenzierte Gebilde dar. Die Mündung ist noch nicht deutlich ausgebildet, in den meisten Fällen fehlt sie völlig, besonders bei grossen Fruchtkörpern

ist sie aber als vorgebildeter, kleiner scheitelständiger Porus angelegt. Die wenig zahlreichen Asci besitzen noch keine Apikalstrukturen. Sie entwickeln sich langsam und unregelmässig; in ein und denselben Gehäuse findet man neben Schläuchen mit reifen Sporen noch völlig unentwickelte. Die verhältnismässig grossen Ascosporen enthalten ein körniges Plasma, benötigen bis zur Reife lange Zeit und besitzen weder Keimporen noch Keimspalten, wohl aber eine Schleimhülle.

Von *Seliniella* lassen sich sowohl die *Polystigmataceae* wie die *Xylariaceae* und wahrscheinlich die *Melanosporaceae*, sowie noch andere unitunicate Pyrenomyceten z.B. die *Nectriaceae* ableiten. Uebergangsformen zwischen *Seliniella* und *Polystigma* D.C. oder *Phyllachora* Nit. als den höchst entwickelten *Polystigmataceae* stellen vor allem die Gattungen *Physalospora* Niessl, dann *Glomerella* Schr. et v. Sp. und *Plectosphaera* Theiss. (alle im Sinne von Von Arx und Müller, 1954) dar. Der Schritt von *Seliniella* zu *Physalospora* ist nur klein, die Vertreter der beiden Gattungen stimmen im Bau der Fruchtschicht, besonders der Asci und Sporen noch fast vollkommen überein, nur fehlt bei *Physalospora* das kompakte, basale Stromagewebe und die dem Substrat bzw. hyphigen Pseudostroma eingesenkten Perithecien besitzen eine charakteristische Form und eine gut ausgebildete Mündung. Mit der Höherentwicklung nimmt die Zahl der Asci auf Kosten der Grösse zu, die Schleimhülle der Sporen verschwindet und bei den höchsten Formen handelt es sich um mehr oder weniger scharf spezialisierte Pflanzenparasiten.

Die nächsten Verwandten der *Seliniaceae* unter den *Xylariaceae* (sensu Von Arx und Müller, 1954) sind bei der ebenfalls coprophilen Gattung *Sordaria* Ces. et de Not. (im Sinne von Cain, 1934) zu suchen. In der Anlage der Fruchtschicht und in der Struktur der Asci finden sich auch da keine Unterschiede, die Höherentwicklung manifestiert sich vor allem durch die papillen – oder kegelförmigen, deutlichen Perithecienmündungen und durch den Keimporus der dunkel gefärbten Ascosporen. Die primitiveren Arten innerhalb der Gattung besitzen Schleimhüllen; die höher stehenden Formen zeichnen sich durch oft kompliziert gebaute Sporenanhängsel aus. Die folgenden Gattungen, die ebenfalls einen Keimporus in den Sporen besitzen gehören in dieselbe Entwicklungsreihe wie *Sordaria*: *Lasiosphaeria* Ces. et de Not., *Lasiosordaria* Chen., *Bombardia* Fr. und *Triangularia* Boedijn. Die Gattung *Neurospora* Shear et Dodge zeichnet sich durch zwei Keimporen und gestreifte Sporen aus. Von ihr können *Ceriophora* v. Höhn. (von Höhnel, 1919) und *Cainia* Müller et von Arx, (1955) abgeleitet werden. Bei den Vertretern dieser Gattungen sind die Ascosporen durch eine Querwand unterteilt und in der Ascusspitze ist ein kompliziert gebauter Apikalapparat ausgebildet (vgl. Müller und Von Arx, 1955).

In die Nähe von *Neurospora* gehören auch die Gattungen *Gelasinospora* Dowd. und *Amphisphaerella* (Sacc.) Kirschst. Bei den Vertretern der letzteren besitzen die Ascosporen vier meist in der Gürtellinie angeordnete, aber oft schwierig sichtbare Keimporen. Als Uebergangsformen zwischen den *Seliniaceae* und den höheren *Xylariaceae* wie den

Vertretern der Gattungen *Anthostoma* Nit. *Rosellinia* de Not., *Hypoxylon* Bull. oder *Xylaria* Hill. ex Grev. können gewisse Vertreter der Gattung *Coniochaeta* (Sacc.) Mass., die zum Teil auf Fäkalien, zum Teil auf Rinde oder Holz wachsen, angesehen werden. Bei dieser Entwicklungsreihe zeichnen sich die übrigens dunkel gefärbten Ascosporen durch einen sich der Länge nach ziehenden Keimspalt aus, ferner besitzen die Asci bei zahlreichen höhern Formen [z.B. *Xylaria* und *Rosellinia* (CHADEFAUD, 1942) oder *Hypocopra* Fr. (MOREAU, 1953)] kompliziert gebaute Apikalstrukturen und die oft mächtigen Stromata erhalten eine hyphig-prosenchymatische Struktur.

Um die Uebersicht zu erleichtern, sind in Abbildung 5 die erwähnten Entwicklungsreihen in Form eines Stammbaumes zusammengestellt. Einige andere, darin ebenfalls erwähnte Ascomyceten-Familien bzw. -Reihen sollen noch kurz besprochen werden.

Ob die *Melanosporaceae* direkt von *Seliniella* oder von mit *Sordaria* oder *Coniochaeta* übereinstimmenden Formen abgeleitet werden müssen, lässt sich ohne die genaue Kenntnis direkter Uebergänge nicht entscheiden. Jedenfalls sind die *Melanosporaceae* hoch entwickelte und abgeleitete Formen. Es handelt sich bei ihnen um Pilze, die auf Uebertragung und Verschleppung der Ascosporen durch Insekten spezialisiert sind. Sie besitzen gewöhnlich verlängerte Mündungen mit einem terminalen Zilienkranz. Bei ihnen verschleimen die Asci früh und die meist mit Keimporen oder Keimspalten versehenen Sporen gelangen mit dem entstehenden Schleim in die Mündung und sammeln sich in deren Spitze in Schleimtröpfchen, die dann durch Insekten besucht und verschleppt werden.

Möglicherweise sind die *Melanosporaceae* phylogenetisch heterogen und stimmen nur in morphologisch-biologischer Hinsicht miteinander überein. Ohne eingehende Untersuchungen lässt sich diese Frage aber nicht entscheiden. Besonders die Gattung *Melanospora* Cda. kennen wir noch sehr wenig; sie bedarf dringend einer monographischen Bearbeitung und die Arten sollten vor allem hinsichtlich des Baues der Fruchtschicht und der Sporen genau untersucht werden.

Wahrscheinlich können noch andere Familien der Sphaeriales wie die *Nectriaceae*, die *Hypocreaceae* oder die *Sphaeriaceae* von *Seliniella* abgeleitet werden. Bei diesen Familien sind uns aber bisher keine Formen bekannt geworden, die sich direkt an *Seliniella* anschliessen liessen.

Betrachtet man einen Schnitt durch einen grösseren, aber mündungslosen Fruchtkörper von *Seliniella macrospora*, dann fällt auch eine weitgehende Uebereinstimmung mit gewissen Vertretern der *Phacidiales*, z.B. mit *Pseudosphacidium ledi* (Alb. et Schw.) Karst. oder mit *Cryptomycina pteridis* (Rebent.) v. Höhn. auf. Die Möglichkeit dass auch hier verwandtschaftliche Beziehungen bestehen, ist jedenfalls nicht von der Hand zu weisen.

Mündungslose Fruchtkörper wie sie für *Seliniella macrospora* die Regel sind, findet man gelegentlich auch bei anderen Vertretern der Sphaeriales. F. MOREAU (1954) z.B. beobachtete derartige Perithecien in Reinkulturen von *Sordaria anserina* (Ces.) Winter, *Sordaria setosa*

Winter (beide sub *Pleurage*), *Chaetomium elatum* Kze. et Schm. und *Magnusia nitida* Sacc.. Bei diesen Arten waren die mündungslosen Perithecien kleiner als die normalen, die Bildung der ascogenen Hyphen war reduziert und es entstanden nur wenige Asci.

Moreau betrachtete diese "frühreifen" Gebilde als eine Rückbildung und spricht von "*néotenie*". Er verglich diese reduzierten Perithecien mit denjenigen der *Erysiphales*, die als unitunicate Pyrenomyceten (vgl. Luttrell, 1951) ebenfalls völlig geschlossene Fruchtkörper besitzen und in denen die Asci direkt aus den paarkernigen, subterminalen Zellen oder aus reduzierten ascogenen Hyphen hervorgehen.

Wir beobachteten nun in unserem Material von *Seliniella macrospora* hie und da rundliche, nur 150–200 μ grosse, völlig geschlossene Fruchtkörper, die nur 2–4 Asci enthielten und die als notreife, reduzierte Gebilde betrachtet werden können. Diese stimmten in ihrem inneren Bau in mancher Hinsicht mit den Fruchtkörpern der *Erysiphaceae* überein. In diesem Zusammenhang möchten wir deshalb auch auf eine mögliche Abstammung der *Erysiphaceae* von mit *Seliniella* übereinstimmenden Formen hinweisen. Die *Erysiphales* sind eine morphologisch sehr einheitliche Pilzgruppe, die als obligate Blattparasiten weit abgeleitet sind und sich biologisch in zahlreiche Kleinarten aufgespalten haben.

LITERATUR

Arx, J. A. von und E. Müller, 1954. Die amerosporen Gattungen der Pyrenomyceten. Beitr. Krypt. fl. d. Schweiz. 11 : 1 439 S.

Cain, R. F., 1942. Studies of coprophilous Sphaeriales in Ontario. Univ. Toronto Studies, Biol. Ser. 38 : 126 S.

Chadefaud, M., 1942. Revue de Mycologie 7 : 57–88.

Höhnel, F. von, 1919. Sitzber. K. Ak. Wissensch. Wien, math.-naturw. Kl. 1. Abt. 128 : 585.

Luttrell, E. S., 1951. Taxonomy of the Pyrenomycetes. Univ. Missouri Studies, 24 : 3, 120 S.

Moreau, C., 1953. Les genres *Sordaria* et *Pleurage*. 330 S. P. Lechevalier, Paris.

Moreau, F., 1954. Huitième Congrès intern. de Bot., Paris, Rapp. et Comm. sect. 19, p. 75.

Müller, E. und J. A. von Arx, 1950. Ber. Schweiz. Bot. Ges. 60 : 329–397.

Müller, E. und J. A. von Arx, 1955. Ueber die Gattungen *Delitschia* Auersw., *Trichodelitschia* Munk und *Cainia* nov. gen. Acta Botanica Neerlandica 4.

Winter, G., 1887. Die Pilze in Rabenhorst, Kryptogamenflora 1^2.

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A CLASSIFICATION SYSTEM FOR THE EPILITHIC ALGAL COMMUNITIES OF THE NETHERLANS' COAST

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Up to now little has been written concerning the algal vegetation of the Dutch coast. Van Goor (1923) was the first investigator who occupied himself with the description of algal communities in our waters; in the western part of the Waddensea and in the former Zuyderzee he distinguished 8 "associations". Some years later Sloff (1925–'26) described the zonation of the *Fucaceae* in the littoral belt of Bergen op Zoom and Koffiehoek (Island of Tholen). This subject was studied again by Zaneveld (1937), who tried to find a correlation between the position of the *Fucaceae* belts at Den Helder and the different tidal levels. Since 1950 the phytocenological study of the Dutch coast was taken in hand by the author with the following intentions: 1 °. to give as complete a description as possible of the epilithic algal communities, 2°. to devise a system for the classification of these communities and 3°. to inquire into the factors which determine differentiation of the vegetation into well-characterized units.

Methods

For analysing the floristic composition of the different vegetation types the survey-method of Braun–Blanquet was used (Kornaś and Medwecka–Kornaś, 1950). In a certain area with a homogeneous vegetation all species were noted with estimations of their abundance and dominance, expressed by means of a figure according to the scale of Braun–Blanquet. In some cases also the sociability was noted. Examples of such surveys have already been published by Kornaś and Medwecka–Kornaś (1950), Waern (1952) [1] and Den Hartog (1953). In Dutch waters we can suffice with this method, since the algal vegetation usually descends no deeper than about $1\frac{1}{2}$ m. below mean low watermark; in deeper water no suitable substrates are present, and there only some solitary algae may be found (Van Goor, 1923). In seas where the algae grow also in deeper water the vegetation can be surveyed by diving (Waern, Kornaś), or by applying a frequency-method to the study of the dredgings (Feldmann, 1938).

[1] Waern used the scale of Hult, Sernander and Du Rietz.

Units

Vegetation-units can be recognized very easily in the field by the dominant species. The boundaries between them are often very sharp, in consequence of the zonation and the differences in physiognomy. The constancy of the floristic composition of a certain vegetation is determined by means of a synthesis of the surveys made in that vegetation. These vegetation-units, characterized by the dominance and the constancy of one or more species, are called sociations (Du Rietz, 1931; Westhoff, 1951).

Moreover, some of these sociations have characteristic species or a characteristic combination of species. Therefore they may be considered associations in the sense of Braun–Blanquet (Westhoff, 1951). Sociations as well as associations are units of the same rank; however, in this paper only the more general term sociation is used.

So far 25 sociations and associations have been observed by the author along the Dutch coast. An account on them will be published later.

In order to obtain a survey of these communities it is necessary to class them into units of a higher order. In phytocenology associations and sociations are classed into alliances (Nordhagen, 1936), according to their floristic similarity. In phycocenology, however, it would as yet be premature to establish alliances, as we do not possess complete descriptions of algal communities from sufficiently large regions. Therefore the formations, the higher vegetation-units, used below, are not based on the floristic principle, but on the physiognomy and the stratification of the vegetation. Moreover, for classing these units the position in the succession-sere and in the zonation are important. These formations are the units of higher rank which for the time being have to be used in algal cenology.

Physiognomy

The physiognomy and structure of the algal vegetations is considered a very important character for their classification. Many authors exclusively described the communities as physiognomic units, without discussing the floristic composition (Kjellman, 1878; Børgesen, 1905; Kylin, 1907; Jonsson, 1912; Van Goor, 1923, a.o.); the conspicuous species only were mentioned. Nevertheless, a good idea of these communities may be formed. This is not surprising, since the variety of forms is much greater in the algae than in the phanerogams. There are gigantic *Laminariaceae* and robust *Fucaceae*, but delicate filamentous algae and minute unicellular forms also occur. Moreover, in taxonomically completely different groups there are quite similar growth-forms; for instance *Ectocarpus* in the *Phaeophyceae*; *Cladophora* in the *Chlorophyceae* and *Callithamnion* in the *Rhodophyceae* represent the same basic life form. Oltmanns (1908), Funk (1927), Nienburg (1930) and some others have tried to construct a system on these variations in growth form. They considered these life forms as ecological adaptations. In a somewhat changed form their system is used by the author.

The most important growth forms of the region are:

1. **Laminaria**-type: *Laminaria, Alaria, Saccorhiza.*
2. **Fucus**-type: *Fucus, Ascophyllum, Pelvetia, Himanthalia, Bifurcaria.*
3. **Cystoseira**-type: *Cystoseira, Sargassum, Halidrys.*
4. **Desmarestia**-type: *Desmarestia.*
5. Crustaceous algae (**Hildenbrandtia**-type), forming crusts closely attached to the substrate; *Hildenbrandtia, Lithothamnion* [1], *Melobesia, Ralfsia, Lithoderma.*
6. Filiform algae (**Ulothrix**-type), monosiphonous and polysiphonous, simple filaments, sometimes with rhizoids: *Ulothrix, Urospora, Gayella, Rhizoclonium, Bangia, Percursaria.*
7. Tubular algae (**Enteromorpha**-type), algae with long, simple or ramified hollow fronds: *Enteromorpha, Blidingia, Asperococcus, Dumontia, Scytosiphon.*
8. Membranaceous algae (**Ulva**-type), forming irregular flat membranes: *Ulva, Monostroma* [2], *Porphyra, Petalonia.*
9. Dendritic algae (**Cladophora**-type), forming branched tufts: *Cladophora* [3], *Bryopsis, Ectocarpus, Sphacelaria, Callithamnion, Ceramium, Cystoclonium.*
10. Fruticose algae (**Chondrus**-type), flat branched ribbonlike or leafy fronds: *Chondrus, Gigartina, Dictyota, Delesseria, Rhodophyllis.*
11. Gelatinous algae (**Nemalion**-type), algae with very gelatinous, branched fronds: *Nemalion, Mesogloia, Scinaia.*
12. Coralline algae (**Corallina**-type), tufted chalk-incrusted forms: *Corallina, Jania.*
13. Pulvinate algae (**Vaucheria**-type), forming cushionlike structures: *Vaucheria, Rhodochorton.*
14. Microscopical algae, algae smaller than 2 mm, which occur singly. Many epiphytes, endophytes and parasites belong to this group.

The various species belonging to the same growth form do not occur singly, but appear, as a rule, collectively; therefore the vegetation types can be characterized by means of the dominant growth form, i.c. with that which determines its physiognomy.

KJELLMAN (1878) was the first who used for these physiognomic units the term "formation". He wrote: "Unter einer Algenformation sollte folglich ein Abschnitt der ganzen Algenvegetation verstanden werden, der durch ein eigentümliches Vegetations-Gepräge ausgezeichnet ist. Im Allgemeinen erhalten diese Abschnitte dadurch dieses Gepräge dass ein oder einige Algenarten die Hauptmasse ihrer Bestandteile ausmachen".

It is clear that this rather vague definition may be interpreted in different ways. According to it all physiognomic units can be regarded as formations. We may speak of a *Pelvetia*-formation, because *Pelvetia canaliculata* gives this vegetation a certain aspect, but with the same right we can speak of a *Fucaceae*-formation, while the joint *Fucaceae* too give the vegetation a certain physiognomic aspect.

In 1905 BØRGESEN proposed to use for the smaller units the term "association". "The associations are often united in a natural way in larger communities, where they live together under the same or very similar biological and ecological conditions. I propose the name of formation for these more comprehensive groups". Thus BØRGESEN distinguished a "*Pelvetia*-association" and a "*Fucaceae*-formation".

Unfortunately BØRGESEN did not use his own distinction consistently; consequently it is not always clear whether he means a formation or

[1] Some species of this genus do not belong to this growth form, e.g. *Lithothamnion calcareum* is better referred to the coralline algae.

[2] *Monostroma groenlandicum* is a tubular alga.

[3] *Cladophora basiramosa* is a filiform alga (it resembles *Rhizoclonium*).

an association. KYLIN (1907) criticized this inconsistency; all units which he could distinguish were called by him "formations".

COTTON (1912) had a completely different conception of "formation" and reserved this term "for communities which occur together in a definite type of habitat". He distinguished only a rocky-shore formation, a sandy-mud formation and a saltmarsh formation. So in this sense a formation is not a phytocenological unit, but a pedological one.

JONSSON (1912) avoided the term formation because in his opinion it has been used in a wrong way by the other phycologists. He distinguished therefore associations only, with regard to which he makes the following remark: "Where I think they are closely allied I combine them into communities". He defined these communities after their dominating life forms (Community of filiform algae; Community of crust algae; Community of *Fucaceae*; Community of *Laminariaceae*; Community of Deepwater-*Florideae*).

SETCHELL (1917), FUNK (1927) and FELDMANN (1938) used the term formation only for the comprehensive vegetation-units which are characterized by the dominating life forms, i.e. in the sense of JONSSON's communities. Therefore KJELLMAN's definition should now be formulated more precisely as follows: An algal formation is a part of the algal vegetation whose aspect is determined by the dominance of a certain life form or the joint dominance of some life forms.

STRATIFICATION

When we analyse a certain algal vegetation, we will find that besides the dominant growth form other growth-types occur; they form the undergrowth and the epiphytes. The congregation of different growth-forms in one community gives the latter a definite stratification. Thus we can distinguish in the *Fucaceae*-communities (*Fucus*-formation) 3 layers: 1 ° a layer of crustaceous algae, 2 °. a layer of dendritic and fruticose algae and 3 °. a *Fucus*-layer; moreover, epiphytic species occur on the *Fucaceae* as well as on the dendritic and fruticose algae. Sometimes one of these layers is absent, but potentially the *Fucus*-formation is three-layered. One-layered (*Hildenbrandtia*-formation), two-layered (*Cladophora*-formation) and four-layered formations (*Laminaria*-formation) occur also along the European coast. Every formation has its characteristic potential stratification.

ZONATION

When we look at the slope of a dike with a well-developed algal vegetation, our attention is immediately drawn to the zonation of the algae. The occurrence of the larger brown algae in belts has of old attracted the attention of algologists; nevertheless little is known concerning the causes of the zonation. The ecologists of the British school (BARKMAN, CHAPMAN, COLMAN, SOUTHWARD, T. A. and A. STEPHENSON, ZANEVELD a.o.) impute the phenomenon to the tidal movement and the complex of factors coupled with it; but along the Swedish West-coast the same zonation occurs independent of the tides (KYLIN, LEVRING, SJÖSTEDT, a.o.).

A zonation of *Chlorophyceae* has been described by HAMEL (1940, 1942) from the Basque coast; in Dutch waters such a zonation, mainly consisting of *Ulvales*, has also been found. Moreover a zonation of *Rhodophyceae* has been discovered, which has its most complete development on the piles which strengthen the Oranjedijk near Vlissingen. There we see from the top downwards the following belts:

1. *Catenella repens*
2. *Callithamnion hookeri*
3. *Ceranium deslongchampii*
4. *Polysiphonia urceolata*

NIENBURG (1930) used growth forms to divide the coastal region into a series of belts, each characterized by a distinct formation (in the modern sense). The present investigations have made his system untenable, since communities typified by completely different growth forms were found at the same level (See the table on p. 131).

SUCCESSION

Very important for a classification system is the phenomenon of succession, which can be studied particularly well along the Dutch coast. By the continuous activities of man on dikes and breakwaters (dumping of stone blocks, renewing of piles, bituminizing of the dike-slope) the vegetation is destroyed again and again. And independent of the season the same algae always colonize the vacant spots in the same manner. Within 6 weeks the stones dumped in the littoral belt are covered with *Enteromorpha*, *Porphyra*, *Ulothrix* and *Ulva*. Later, all kinds of dendritic algae settle among them, and soon also the first germlings of the *Fucaceae* appear. After some years the whole spot has been occupied by the *Fucaceae*, each in its own belt. The undergrowth consists of dendritic algae; only a few tubular and membranaceous algae occur at that stage. In other localities establishment of *Fucus* between the *Enteromorpha*-vegetátion progresses more slowly or sometimes entirely fails. In that case dendritic and fruticose algae get a chance of succeeding the *Enteromorpha-Porphyra*-sociation and not being untimely superseded by the *Fucaceae* they may form a luxurious growth. On the bituminized northern mole of Harlingen a luxurious community of *Ceranium deslongchampii* has succeeded the *Enteromorpha-Porphyra*-sociation, as on bitumen *Fucaceae* do not grow at all or only poorly.

In localities exposed to the surf and at the same time strongly washed with sand, e.g. on breakwaters along the beach, the *Enteromorpha-Porphyra*-sociation maintains itself permamently.

It is remarkable that the succession has a divergent character, the terminal stages being more numerous than the initial ones. In the tidal zone only two pioneer communities occur. The *Blidingia*-sociation, wich occurs in the upper part of the littoral belt, develops into 2 terminal stages, viz. the *Pelvetia*-sociation and the *Fucus spiralis*-sociation. The low-littoral *Enteromorpha-Porphyra*-sociation, which is completely homogeneous, differentiates even into 4 terminal stages.

Looking at the table one will observe that in the littoral belt all terminal stages except one have relation to the sociations of the large

brown seaweeds. Between the belts of *Fucus serratus* and *Laminaria* along the coasts of the Channel (BEAUCHAMP, 1914; DAVY DE VIRVILLE, 1940), in the Faeröes (BØRGESEN, 1905) and along the Norwegian Westcoast (LEVRING, 1937) a belt of *Himanthalia elongata* occurs. Along the Dutch coast *Himanthalia* cannot grow, and its sociation is replaced by the *Polysiphonia-Chaetomorpha*-sociation, in which mainly dendritic and fruticose algae are represented. The latter sociation is not a real terminal stage but it maintains itself because the circumstances for the establishment of the terminal *Himanthalia* sociation are not realized. Also in the sublittoral a place has been left open, because the communities of *Desmarestia* and of *Cystoseira* are wanting in the Netherlands.

THE CLASSIFICATION SYSTEM

The discussion of the stratification as well as of the succession has shown that the formations are not all equivalent from a structural

THE ALGAL COMMUNITIES OF THE DUTCH COAST

<table>
<tr><td rowspan="2">Supra-littoral</td><td rowspan="2">"Buff zone"</td><td>Prasiola</td><td rowspan="2" colspan="2"></td><td rowspan="2">M.H.W.</td></tr>
<tr><td>Bangia-Urospora</td></tr>
<tr><td rowspan="6">Eulittoral</td><td rowspan="6">Hilden-brandtia</td><td rowspan="2">Blidingia</td><td rowspan="2">Catenella</td><td>Pelvetia</td><td rowspan="6">M.L.W.S.</td></tr>
<tr><td>Fucus spiralis</td></tr>
<tr><td rowspan="4">Enteromorpha compressa-Porphyra + Enteromorpha intestinalis</td><td>Callithamnion hookeri</td><td rowspan="2">Ascophyllum + Fucus vesiculosus</td></tr>
<tr><td rowspan="2">Ceramium deslongchampii + Chondrus + Gigartina</td></tr>
<tr><td>Fucus serratus</td></tr>
<tr><td>Polysiphonia-Chaetomorpha</td><td></td></tr>
<tr><td>Sublittoral</td><td></td><td>Ulva</td><td>Codium-Hypoglossum</td><td></td><td>Laminaria</td></tr>
</table>

EXPLANATION OF THE TABLE

From left to right the communities are arranged according to their sociological progression. In general outline this classification corresponds to the succession, but there are some important deviations (e.g. the place of the *Hildenbrandtia*-sociation). From the top downwards the communities are classed according to their place in the zonation. Sometimes more than one community of a formation occurs in the zonation at the same level; in that case they have in other respects different ecological preferences; for instance the *Ascophyllum*-sociation occurs in very sheltered localities and avoids more exposed ones, while on the contrary the *Fucus vesiculosus*-sociation prefers more exposed spots.

One community, viz. the *Monostroma- Dumontia*-sociation,which occurs in littoral pools, could not be fitted into the table without deviating from general plan.

Mean high water mark (M.H.W.) is fixed as the upper limit of *Balanus balanoides*.

Mean low water mark at springtide (M.L.W.S.) is leveled with the upper limit of the *Laminaria*-vegetation in the Waddensea and with the *Codium*-vegetation in the province of Zeeland. It is clear that the corresponding tidal levels of an exposed and a sheltered coast do not coincide (DU RIETZ, 1940, 1947).

point of view. The communities which possess a life formpattern consisting of tubular and membranaceous algae, form the little differentiated pioneer vegetation, whereas the terminal stages are formed by the highly organized *Fucaceae*- and *Laminaria*-sociations. The communities of the dendritic and fruticose algae are only transitional stages in the succession. Thus it is possible to arrange the formations according to their position in the succession and their degree of organisation, in short to their sociological progression.

Along the Dutch coasts 7 formations can be distinguished:

1 °. **Hildenbrandtia**-formation, an one-layered formation of crustaceous algae which can develop into more highly organized formations. To this formation belong among others the *Hildenbrandtia prototypus*-sociation and the supralittoral "buff zone" (T. A. and A. Stephenson, 1954), a belt of nigrescent *Cyanophyceae* and *Protococcacae.* Also the supralittoral lichen-vegetation in which *Verrucaria maura*, *Caloplaca marina*, *Xanthoria parietina*, etc. occur, may be included in this formation.

2 °. **Prasiola**-formation, a two-layered formation of filiform and small membranaceous algae which are confined to supralittoral nitrate-rich stones.

Along the Dutch coast only the *Prasiola stipitata*-sociation occurs.

3 °. **Bangia**-formation, a two-layered pioneer formation of filiform algae, which is a permanent stage in the supralittoral belt.

The supralittoral *Bangia-Urospora*-sociation may be classed in this formation.

4 °. **Enteromorpha**-formation, a two-layered pioneer formation of tubular, membranaceous and filiform algae. The *Blidingia*-sociation and the *Enteromorpha-Porphyra*-sociation have to be assigned to it.

The three last-mentioned formations correspond in some respects; therefore also other classifications have been proposed. For instance in the Faeröes Børgesen (1905) distinguished between 1°. a "*Chlorophyceae*-formation", which includes the *Prasiola*-formation and a part of the *Enteromorpha*-formation, 2°. a "*Porphyra*-association", belonging to the *Enteromorpha*-formation, and 3°. a "*Bangia-Urospora*-association". The system of Jonsson (1912) resembles much more the classification proposed here, for he distinguished between 1°. a "*Prasiola stipitata*-association", 2°. a "Community of filiform algae" and 3°. an "*Enteromorpha*-association". He incorporated, however, the "*Porphyra*-association" into the community of filiform algae, which for the rest corresponds totally with the *Bangia*-formation.

The distinction between the *Bangia*- and the *Enteromorpha*-formation is not always clear because the filiform alga *Ulothrix flacca* often is abundant in the littoral communities of the latter formation. In most cases *Enteromorpha* or *Porphyra* are the dominant genera, but in some localities in the Wadden Sea *Ulothrix flacca* is sometimes predominant. As such a vegetation of *Ulothrix flacca* is only a variant of the *Enteromorpha*-vegetation mentioned above, the author regards it in spite of the filiform structure of the dominant as such.

5 °. **Cladophora**-formation, a two-layered formation in which dendritic and fruticose algae are dominant. It may be considered as a transitional formation arising from communities of the *Enteromorpha*-formation and developing into the formations of the large brown algae.

The *Polysiphonia-Chaetomorpha*-sociation (Van Goor, 1923) may be classed in this formation.

6°. **Fucus**-formation, a three-layered formation of *Fucaceae*. It is the terminal formation in the littoral succession. Members of this formation are, in the Netherlands, the *Pelvetia*-sociation, the *Fucus spiralis*-sociation, the *Ascophyllum*-sociation, the *Fucus vesiculosus*-sociation and the *Fucus serratus*-sociation.

7°. **Laminaria**-formation, a four-layered formation of *Laminariaceae*. It is the terminal formation in the (upper) sublittoral succession-sere.

Along the Dutch coast this formation is three-layered. In the boreal seas where the *Laminaria*-formation has its most luxurious development, a fourth layer consisting of *Desmarestia* species occurs in the undergrowth (Børgesen, 1905; Kylin, 1907; Jonsson, 1912). In the Channel the *Desmarestia*-layer sometimes is replaced by a *Cystoseira*-layer.

Most of the formations occur not only on the tidal coast, but are found also — partly in the form of other sociations — in the seawater canals of Walcheren and Zuid Beveland, where tides are failing. Only the *Fucus*- and *Laminaria*-formation are restricted to the tidal coast, at least in the Netherlands. The other formations, except that of *Prasiola* [1] are widely distributed in brackish waters too. The *Enteromorpha*-formation disappears at the transition from brackish into fresh water, although in auxotrophiated fresh water *Enteromorpha* species may occur. Finally, only three formations occur in sea as well as in fresh water, viz. the *Hildenbrandtia*-, *Bangia*-, and *Cladophora*-formations.

References

Anand, P. L., 1937. An Ecological Study of the Algae of the British Chalk-cliffs; Journ. of Ecol. 25 : 153–188, 344–367.

Barkman, J. J., 1950. Wierzonering in het littoraal; Vakbl. v. Biol. 30 : 1–14.

Beauchamps, P. de, 1914. Les Grèves de Roscoff. Etude sur la répartition des êtres dans la zone de marées — Paris.

Børgesen, F., 1905. The Algae-Vegetation of the Faeröese Coasts, with remarks on the Phyto-Geography; Botany of the Faeröes 2 : 683–834.

Braun-Blanquet, J., 1951. Pflanzensoziologie, 2e edition, Wien.

Braun-Blanquet, J., 1951. Pflanzensoziologische Einheiten und ihre Klassifizierung; Vegetatio 3 : 126–233.

Chapman, V. J., 1942. Zonation of Marine Algae on the Sea-shore; Proc. Linn. Soc. London 154 : 239–253.

Chapman, V. J., 1944. Methods of surveying Laminaria-beds; Journ. Mar. Biol. Assoc. 26 : 37–60.

Chapman, V. J., 1946. Marine Algal Ecology; Botanical Review 12 : 628–672.

Chapman, V. J. & C. B. Trevarthen, 1953. General schemes of classification in relation to marine coastal zonation; Journ. of Ecol. 41 : 198–204.

Colman, J., 1933. The nature of the intertidal Zonation of plants and animals; Journ. Mar. Biol. Ass. 18 : 435–476.

Colman, J., 1940. On the faunas inhabiting intertidal seaweeds; Journ. Mar. Biol. Ass. 24 : 129–183.

[1] *Prasiola*-vegetations have been found on the banks of some Swedish lakes (Waern, 1952). In the Netherlands an aerial *Prasiola crispa*-community is common on the trunks of trees.

Colman, J., 1942. Some Intertidal Enigma's; Proc. Linn. Soc. London 154 : 232–234.
Cotton, A. D., 1912. Marine Algae of Clare Island; Proc. Roy. Irish Acad. 31.
Davy de Virville, A., 1932, Les zones de Lichens sur le littoral atlantique; Bull. de Mayenne-Sciences 1931-32 : 1–34.
Davy de Virville, A., 1940. Les zones de Végétation sur le littoral atlantique; Soc. Biogeogr. 7 : 205–251.
Feldmann, J., 1938. Recherches sur la Végétation marine de la Méditerranée. La côte des Albères; Rev. Alg. 10 : 1–339.
Feldmann, J., 1951. Ecology of marine algae; in Smith: Manual of Phycology — an Introduction to the Algae and their Biology, 313–334.
Funk, C., 1927. Die Algenvegetation des Golfs von Neapel; Pubbl. St.-Zool. Napoli 7.
Goor, A. C. J. van, 1923. Die Holländischen Meeresalgen; Verh. Kon. Akad. Wetensch. Amsterdam, 2e sect, 23–2.
Hamel, G., 1940. Les ceintures de Chlorophycees de la côte basque française. Rev. gén. Bot. 52 : 433–439.
Hamel, G., 1942. Sur les Chlorophycées de la côte basque française et leur répartition en ceintures; Blumea, suppl. 2: 41–51.
Hartog, C. den, 1953. Porphyra leucosticta along the Dutch Coast; Acta Bot. Neerl. 2 : 308–315.
Hoffmann, C., 1933. Die Vegetation der Nord- und Ostsee; Grimpe-Wagler, Tierwelt der Nord- und Ostsee Ie.
Johnson, D. S. & A. F. Skutch, 1928. Littoral Vegetation on a headland of Mt. Desert Island, Maine; Ecology 9 : 188–215, 307–338, 429–488.
Jonsson, H., 1912. The Marine Algal Vegetation of Iceland; The Botany of Iceland 1 : 1–186.
Kitching, J. A., 1937. Studies in sublittoral ecology II, Recolonisation at the upper-margin of the sublittoral region; with a note on the denudation of Laminaria-forest by storms; Journ. of Ecology 25 : 482–495.
Kjellman, F. R., 1878. Über Algenregionen und Algenformationen im östlichen Skagerrak; Bih. t. Kgl. Svenska Vet. Akad. handl. 5–6 : 1–35. Stockholm.
Kornaś, J., & A. Medwecka-Kornaś, 1950. Associations végétales sous-marines dans le Golfe de Gdansk; Vegetatio 2 : 120–127.
Koster, J. Th., 1952. Rare or otherwise interesting Marine Algae from the Netherlands; Acta Bot. Neerl. 1 : 201–215.
Kylin, H., 1907. Studien über die Algenflora der Schwedischen Westküste. — Thesis. Uppsala.
Kylin, H., 1918. Svenska Västkustens algregioner; Svensk. Bot. Tidskr. 12 : 65–90.
Levring, T., 1937. Zur Kenntniss der Algenflora der norwegischen Westküste; Lunds Univ. Årsskr. N. F. 2, 33–8 : 148 p.
Levring, T., 1940. Studien über die Algenvegetation von Blekinge, Südschweden. — Thesis. Lund.
Nienburg, W., 1930. Die festsitzenden Pflanzen der Nord-europäischen Meere; Handb. der Seefischerei 1: 1–52, Stuttgart.
Oltmanns, F., 1922-23. Morphologie und Biologie der Algen, Jena.
Rietz, E. G. Du, 1940. Das limnologisch-thalassologisch Vegetationsstufensystem; Verhandl. der Int. Ver. für theor. u. angew. Limn. 9 : 102–110.
Rietz, E. G. du, 1947. Wellengrenzen als ökologische Äquivalente der Wasserstandslinien; Zool. Bidr. fr. Uppsala 25 : 534–550.
Setchell, W. A., 1917. Geographical distribution of the marine Algae; Science N.S. 45 no. 1157 : 197–204.
Sjöstedt, L. G., 1928. Litoral and Supralitoral Studies on the Scanian Shores; Lunds Univ. Årsskr. N. F. 24, 36 p.
Sloff, J. G., 1925–26. Wierglooiingen; De Levende Natuur 29 : 321–328; 353-360; 30 : 321–327.
Southward, A. J., 1953. The Ecology of some rocky shores in the south of the Isle of Man; Proc. and Trans. Liverpool Biol. Soc. 59 : 1–50.
Stephenson, T. A., 1942. The causes of the vertical and horizontal distribution of the organisms between the tide marks in South Africa; Proc. Linn. Soc. London 154 : 219–232.
Stephenson, T. A., & A., 1949. The Universal features of zonation between tide-marks on rocky coasts; Journ. of Ecol. 37 : 289–305.

STEPHENSON, T. A., & A., 1950. Life between Tide-marks in North America. I. The Florida Keys; Journ. of Ecol. 38 : 354–402.

STEPHENSON, T. A., & A., 1954. Life between Tide-marks in North America. III. Nova Scotia and Prince Edward Island; Journ. of Ecol 42 : 14–70.

WAERN, M., 1952. Rocky-Shore Algae in the Öregrund Archipelago; Acta Phytogeographica Suecica 30, Uppsala.

WESTHOFF, V., 1951. An analysis of some concepts and terms in vegetation study or Phytocenology; Synthese 8 : 194–206.

WOMERSLEY, H. B. S., & S. J. EDMONDS, 1952. Marine coastal zonation in Southern Australia in relation to a general scheme of classification; Journ. of Ecol. 40 : 84–90.

ZANEVELD, J., 1937. The littoral zonation of some Fucaceae in relation to desiccation; Journ. of Ecol. 25 : 431–468.

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NOTES ON GUIANA DROSERACEAE

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A study of the Suriname species of the genus *Drosera* revealed the existence of a few problems and led to some new points of view with regard to the taxonomy of the tropical American species of this genus. A discussion of these problems (and an exposition of my views) including the description of a new species, are given in the following pages.

According to the "Enumeration of the vascular Plants known from Surinam", published by A. A. Pulle in 1906, no species of *Drosera* were at that time known from Suriname. In the same year L. Diels published his monograph of the *Droseraceae* in "Das Pflanzenreich". He mentioned from Guiana the following species: *Drosera sessilifolia* St. Hil., *D. cayennensis* Sagot ex Diels, *D. capillaris* Poir., *D. montana* St. Hil. var. *roraimae* Diels and, with some hesitation, *D. pusilla* H.B.K. and *D. tenella* Willd. Consequently at least part of these species were to be expected from Suriname. Investigation of herbarium specimens revealed a great confusion, especially with regard to the species *D. pusilla* H.B.K., *D. tenella* Willd. and *D. capillaris* Poir. At a first glance hardly any difference seemed to exist between *D. pusilla* and *D. tenella*, as the diagnostic characters, mentioned by Diels, viz. length and number of peduncles, proved to be of no value. After examining the type collections of these two species however, a real difference, which proved to have been mentioned already by Kunth, was found in the seeds. *D. pusilla* has subglobular and foveolate seeds, whereas the seeds of *D. tenella* are ovoid, longitudinally ribbed and papillose. In the general appearance of the plants another difference was found: the flowers of *D. tenella* proved to be proportionally smaller and the peduncles more slender and usually somewhat longer than in *D. pusilla*. When *D. pusilla* is defined in this way, it appears that it is up till now only known from Venezuela and Brazil, and not from Guiana.

The next problem regarded the differences between *D. tenella* Willd. and *D. capillaris* Poir. According to Diels and other authors, the principal differences are to be found in the hairiness of the petiole, in the size of the plants and in the number of flowers. Examination of herbarium specimens showed that these characters are not at all constant; and that intermediates between *D. tenella* and *D. capillaris* exist. Besides, it proved to be impossible to find a difference between

the seeds of these two species. As the seeds of the *Drosera* species were generally found to possess constant and reliable specific characters, *D. tenella* Willd. and *D. capillaris* Poir. are to be considered conspecific and as the name *Drosera capillaris* Poir. has priority, this combination will have to be retained.

In the author's opinion *D. tenella* var. *esmeraldae* Steyerm. (described by Julian A. STEYERMARK in Fieldiana Bot. Vol. 28, n. 2, 1952, p. 244) from Venezuela, cannot belong to this species as its seeds are not papillose but marked with pits that are more or less arranged in rows.

Drosera capillaris Poir. must be considered the most common species of this genus in Suriname. This was recognised also by MAGUIRE who, however, identified the species incorrectly, using the name *D. pusilla* (Bull. Torr. Bot. Cl. 75, 1948, p. 642).

A species new for this region (known already from Europe, Eastern North America as far southward as Texas, and from Cuba), and rather frequent, is *Drosera intermedia* Hayne. In Suriname it has been collected three times by Lanjouw and Lindeman in 1948, along the Moengo tapoe line.

Maguire 24432 and 24486 (collected on Mt. Tafelberg in 1944) were incorrectly identified as *D. capillaris*; both collections belong to *D. intermedia.*

D. capillaris and *D. intermedia* are well characterized by their mature seeds (clearly figured in a drawing published by F. E. WYNNE in Bull. Torr. Bot. Cl. 71, 1944, p. 173). The seeds of the latter species are irregularly and densely papillose and those of the former corrugated papillose, the papillae being arranged in longitudinal rows. It is noteworthy that *D. intermedia* may have pink and purple flowers and that it is not, as usually mentioned, always white-flowered.

Drosera cayennensis Sagot ex Diels, described by DIELS from French Guiana, has only once been collected in Suriname. The species is characterized by its glandular pilose peduncles, its oblong, erect and glandular, pilose sepals and by its leaves being glabrous beneath.

Maguire and Fanshawe collected in 1944, in the Kaieteur savanna in British Guiana, a plant which was identified by L. CROIZAT, according to the label, as *D. cayennensis.* It does not belong, however, to this species from which it differs by the withered sepals becoming recurvate, by the presence of long hairs on the abaxial side of the petiole and along the margin on the lower side of the leaf, and by the apiculate and reticulate seeds. Consequently this specimen must be regarded as belonging to a new species:

Drosera kaieteurensis nov. sp.

Caulis brevissimus. Folia rosulata conferta patentia. Stipulae membranaceae, basi petiolo adnatae, ceterum fere in segmenta 3 lineari-lanceolata partitae, 3–5 mm longae. Petiolus planus, 3–10 mm longus, subtus villosus. Lamina rotundato-obovata, subtus marginem versus villosa. Pedunculi et pedicelli nunc pilis longioribus crispatis et pilis glandulosis brevioribus conspersi, nunc glabrescentes. Sepala villosa glandulosa ovata acutiuscula, plm. 3 mm longa, post anthesim apice recurvata. Styli 3, e basi bipartiti; stigmata paulum incrassata (plm.

capitata). Semina ovoideo-subglobosa, apiculata, nitida, circ. 0.3 mm longa.

Typus: Maguire and Fanshawe 23466 in herbario NY; duplicato in herbario K — Guiana britannica in Kaieteursavanna.

It appeared that this species has already been collected during the last century, but not recognised as a distinct species. E.g. the following herbarium specimens, studied by the present author, belong to it: Im Thurn (1878) in K; Jenman n. 912 and 1293 (1882) in K, all from the Kaieteur savanna; herb. Trin. n. 14932 and 15084 in K from Trinidad, Steyermark n. 59970 and 6049 in F from Venezuela.

Steyermark described (in Fieldiana Bot. Vol. 28 nr. 2, 1952, p. 243) a new species named *Drosera sanariapoana* Steyerm., which, however, in my opinion, is identical with *D. cayennensis* Sagot ex Diels. As a difference between his new species and this one he mentioned less hairy and longer peduncles and sepals. Two specimens of his collection, however, viz. the above mentioned n. 59970 and 6049, which has been labelled *D. cayennensis*, turned out to belong to another species, viz. to *D. kaieteurensis*. Examination of the type specimens of *D. cayennensis* and *D. sanariapoana* showed that they are conspecific, so that the latter name must be regarded as a synonym.

Another plant, which is known from Mt. Roraima and can possibly be expected in Suriname, is *D. montana* St. Hil. var. *roraimae* Diels. The species is, according to Diels, represented by 6 varieties; four of them are recorded from South Brazil, and two from Mt. Roraima, viz. var. *roraimae* Diels and var. *robusta* Diels (Notizbl. Berlin VI. 54, 1915, p. 136). These two varieties seem to be identical and the latter may therefore be considered a synonym. A more detailed study will be needed to decide whether the var. *roraimae* and the four varieties recorded from South Brazil, really belong to one and the same species. Their geographical distribution seems to show a noteworthy disjunction.

This investigation has been carried out at the Botanical Museum and Herbarium of the State University Utrecht (Director: Dr. J. Lanjouw). I wish to express my sincere thanks to the directors of the herbaria at Chicago, Kew, Leiden, München, New York and Paris for the loan of herbarium specimens. I especially want to acknowledge the valuable information which I received from Mr. N. Y. Sandwith (Kew) with regard to these plants.

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EXPERIMENTS ON THE RELATION BETWEEN WATER ABSORPTION AND MINERAL UPTAKE BY PLANT ROOTS

BY

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Introduction

During the last decades several investigators have studied the question whether ion absorption in living plants is accelerated by the transpiration stream. Up to 1953 opinions more or less counterbalanced each other. About two thirds of the experiments gave evidence of a measurable promotion of the ion intake by water absorption, whereas one third seemed to prove a more or less complete independence between the two. To the first category belong the results of Schloessing (1896), Sorauer (1880), Haas and Reed (1927), Schmidt (1936), Freeland (1937), Bötticher and Behling (1939), Van der Wey (1936), Wright (1937) and of Phillis and Mason (1940), to the second those of Hasselbring (1914), Kiesselbach (1916), Mendiola (1922), Muenscher (1922), Huber (1923), Gracanin (1932), Kreyzi (1932) and Van den Honert (1933). Recently, however, the scale seems to have been turned definitely in favour of the first named view by the investigations of Petrischek (1953), Hylmö (1953) and Brouwer (1953, 1954).

Petrischek (1953) and with him Huber (1954) describe the ion absorption in its relation to water transport as consisting of two parts, the first independent of transpiration, the second proportional to it. This second part, which is indicated by Hylmö as "phase III" is shown by this last author to be of prominent importance in the ion intake by pea roots.

Brouwer (1953, 1954) obtained results similar to those of Hylmö. However, as will be discussed later on, the two authors differ in their interpretation of the phenomenon.

When considering this question it may be useful to state precisely what we want to know. There is no lack of evidence that the transpiration stream in the xylem carries salts and that by intensification of the transpiration stream the salt transport towards the leaves is increased (Haas and Reed 1927, Petrischek a.o.). These salts are ultimately derived from the roots, which in turn absorbed them from

the medium. Now it is well known that plant tissues in general and roots in particular are able to accumulate ions only to a certain extent. ROBERTSON (1940), SUTCLIFFE (1952), HOAGLAND and BROYER (1942), HUMPHRIES (1952) and others showed that the rate of salt absorption is closely dependent on the salt concentration in the tissues and that a high concentration as a consequence of a previous absorption will hamper a further accumulation of the ions in question. If the transpiration current is effective in expediting translocation of minerals from the roots, it will also be effective in ion absorption because by its action the vacuolar concentration will be lowered. According to authors like PHILLIS and MASON (1940), BROYER and HOAGLAND (1943) and HOAGLAND (1944) it is in this way that ion absorption is promoted by transpiration.

However, we may confine ourselves to the more restricted question, whether, given a certain, constant status of the plant, the rate of entrance of ions from the environment into normally living roots is increased by water absorption. If the problem is stated like this, several investigations usually cited in this connection fail to give us an answer. All those, which are concerned with salt transport inside the plant, either by measuring the accumulation of salts in leaves as influenced by transpiration (HAAS and REED 1927, BÖTTICHER and BEHLING 1940) or by measuring concentration and rate of flow of the xylem sap (PETRISCHEK 1953) may at most give us certain indications.

But also in these cases where, in comparison to the water absorption, the actual intake into the roots was measured, the results are not always decisive. HYLMÖ rightly criticises the experimental procedure in a number of cases, although he limits his criticism to the results which do not agree with his views (l.c. p. 377).

An experiment proving — or disproving — an accelerating influence of water transport on ion intake should meet the following requirements. As stressed by HOAGLAND (1944) and HYLMÖ (1953) the experimental times should be short. During the periods of high and low transpiration to be compared the plant should be kept as much as possible in a constant status as far as vacuolar salt concentration, carbohydrate supply etc. are concerned, not to mention structural differences, which will develop in experiments lasting weeks or months. In other words, when applying high and low transpiration conditions alternatingly the plants should not have time "to change their minds".

The root environment should be kept constant in respect to temperature and pH and well stirred and aerated. If no stirring takes place the roots may deplete their immediate surroundings, so that ions will have to diffuse through an adhering water layer in order to reach the root surface, which process may limit the rate of uptake. For this reason the results obtained with roots in soil or sand cultures are doubtful. As stated by OLSEN (1953) stirring is the more effective the more the nutrient solution is diluted. HYLMÖ, finding no effect of stirring, used fairly concentrated solutions of 1–16 mM $CaCl_2$. It seems probable, however, that SCHMIDT (1936) putting the roots of

his *Sanchezia* plant into a narrow potometer vessel soon brought them into an asphyxiated condition (VAN DEN HONERT 1938). This opinion is not shared by HYLMÖ (l.c. p. 379).

Meanwhile, also several experiments made with a more satisfactory water culture technique, like those of FREELAND (1937) and WRIGHT (1939) give evidence of a decided influence of transpiration on mineral intake. However, "the increase in amount of salt absorbed was by no means proportional to the increase in amount of water absorbed by the more rapidly transpiring plants" (KRAMER 1949).

The most prononced arguments in favour of the promoting influence of the transpiration stream on ion intake are found in HYLMÖ's experiments. Working with 20 day-old, intact pea seedlings he stated that the intake of calcium and chloride from 1–9 mM $CaCl_2$ solutions was roughly proportional to the water absorption and also to the concentration. This would point to a passive intake of ions with the transpiration flow, a wick-like mechanism. However, the concentration of the "transpiration current" proved to be mostly lower than that in the medium. According to HYLMÖ this could be explained by the assumption that cell walls and cytoplasm would permit the passage of both water and salts, whereas the tonoplasts would be permeable to water only.

Apart from this passive mechanism, designated by him as "phase III", HYLMÖ discerns two more absorption mechanisms. "Phase I" is the rapid intake by roots or tissues placed into a more concentrated solution, also proceeding at 0° C and independent of transpiration. It is concerned with the hypothetical "free space" in the tissue which is calculated by HYLMÖ to amount to 8 per cent of the volume of the pea roots. Finally, the process by which ions are accumulated into the vacuoles by means of respiration energy is referred to by him as "phase II". The phase III component, dependent on transpiration, seems to be conspicuously prominent in pea roots.

BROUWER (1954) who, incidentally, could confirm HYLMÖ's results with pea seedlings (l.c. p. 306) studied the intake of water and ions in different zones of secundary roots of intact *Vicia faba* plants. By means of a very elegant experimental procedure he was able to show that by increasing the suction tension of root cells by one means or another the water conductivity of the different root zones investigated was increased to different degrees, so that at higher suction tensions the zone of maximum water absorption shifted away from the root tip, as previously found by BREWIG (1937). However, also the uptake of the anions (nitrate, phosphate and chloride) was influenced in the same way, although to a somewhat less degree. In contrast to HYLMÖ, he considers salt and water uptake as governed by separate mechanisms. In his opinion salt absorption, though its speed is correlated to that of transpiration, still remains an entirely active process. Increased transpiration, by causing an increased suction tension in the living root cells, would promote the rate of ion intake bij an increase of "ion conductivity" in these cells.

Although differing in their explanation of the phenomena, both

HYLMÖ and BROUWER lay stress on the pronounced influence of transpiration on ion uptake by plant roots. In this connection it seems appropriate to mention some experiments made in the former Dutch East Indies which escaped attention because they were published in unaccessible periodicals.

Firstly, VAN DER WEY (1936), measuring the intake of water during consecutive hours of the day in aerated water cultures of big tobacco plants and simultaneously following the course of the salt intake by means of conductivity measurements, found a pronounced increase in salt intake during the hours of strong transpiration (Fig. 1).

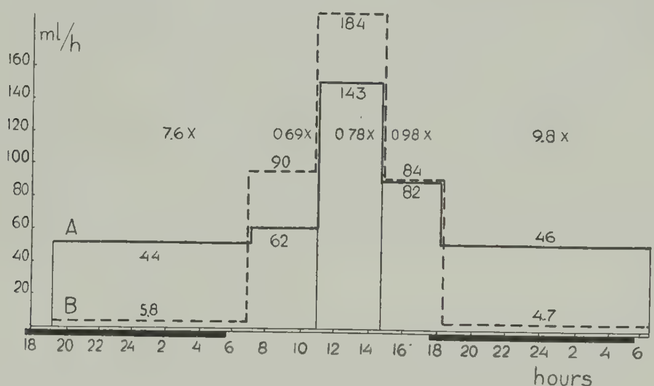

Fig. 1. Tobacco. A. Ion absorption in terms of ml nutrient solution in which the absorbed ions were solved. B. Water intake. Both expressed as ml/h per m² leaf surface. (After VAN DER WEY, 1936).

Also in this case, however, the ion absorption was by no means proportional to the water uptake. The increased ion absorption may have been due partly to an increase in temperature, as no precautions were taken to keep the root temperature constant.

On the other hand, VAN DEN HONERT, working with intact sugar cane plants in water cultures, obtained completely opposite results. He used a method of continuously flowing water cultures (1933), a description of which will be recapitulated in a following publication. The apparatus enabled him to regulate concentrations and pH in the culture solution at will and measure ion and water absorption at the same time. The nutrient solution was stirred and aerated by a constant stream of air. Phosphate absorption was determined by colometric analysis of the solution.

With this method he studied the rate of absorption of phosphate in intact sugar cane roots as influenced by environmental factors including concentration, pH, temperature and also transpiration rate. In the experiments mentioned below a pH 6 was maintained throughout.

Firstly, it appeared that the relation between the rate of phosphate absorption and concentration was represented by an asymptotic curve, already reaching a maximum at a phosphate concentration of 1 p.p.m. (Fig. 2). That means that the concentration factor has a negligible influence on the rate of uptake between 1,6 and 2,1 p.p.m.

Keeping the phosphate concentrations between these limits, the rate of phosphate uptake by one sugar cane plant was studied during five consecutive days and nights (Fig. 3). Although during the hours of sunshine the transpiration rate increased to tenfold or more above the night values, the phosphate absorption was but little affected. In these experiments the root temperature was not kept constant but varied as represented in the graph. In a later set of experiments a thermostat was constructed and the influence of temperature on the rate of phosphate absorption was studied, again between the above concentration limits and at pH 6, showing between 25° and 35° C a practically direct proportion to the number of degrees centigrade. Therefore, the variations in the rate of phosphate absorption shown in fig. 3 must have been due mainly to the temperature variations of the roots. It is clear that the influence of transpiration on phosphate

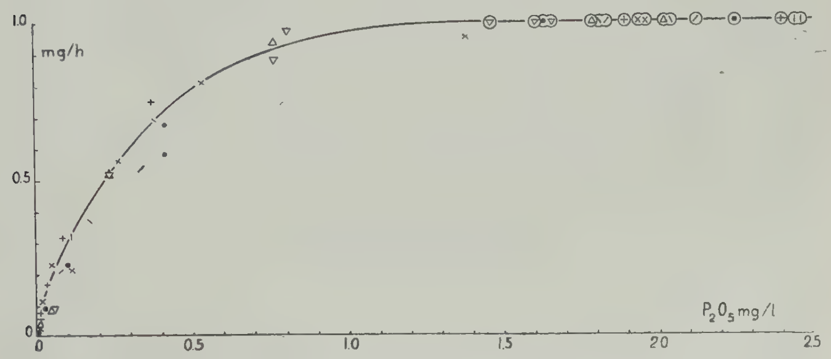

Fig. 2. Sugar cane. Relation between phosphate concentration and rate of phosphate absorption at pH 6. (After VAN DEN HONERT, 1932).

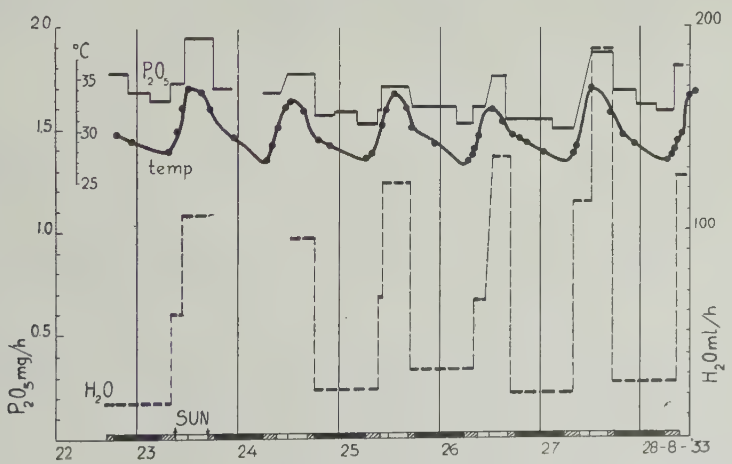

Fig. 3. Sugar cane. Rate of water and phosphate absorption by one plant during several days. Root temperature indicated. (After VAN DEN HONERT, 1932).

absorption in sugar cane roots, if any, is certainly small and hardly exceeds the experimental errors. For this reason the (possibly somewhat premature) general conclusion was drawn that transpiration has hardly any influence on phosphate intake and that the two processes are relatively independent of each other.

Another argument appeared in favour of this view. At very low concentrations (0,01 p.p.m.) and at the lowest transpiration rates during the nightly hours, the rate of phosphate intake appeared to be 500 times that calculated for passive absorption of the unchanged nutrient solution. To use HYLMÖ's terms, it was "phase II" that determined the rate of uptake in these experiments and the contribution of "phase III" to the phosphate uptake was negligible, completely different from HYLMÖ's experiences with *Pisum*.

However, because a few years later SCHMIDT (1936) published his much-cited research on the water and salt intake in the Acanthacea *Sanchezia nobilis*, the results of which were completely at variance with the above mentioned ones, VAN DEN HONERT (1938) studied the rate of phosphate and nitrate intake in this same object. The species name is not a warrant that exactly the same species has been used in both cases, as some confusion seems to be possible especially in this case. The two species studied were in any case very closely related.

With the same technique of continuously flowing water cultures the nitrate and phosphate intake was determined during a period of twice 24 hours and compared to the water intake during the same period. In this case the root system was kept at a constant temperature of 28°C.

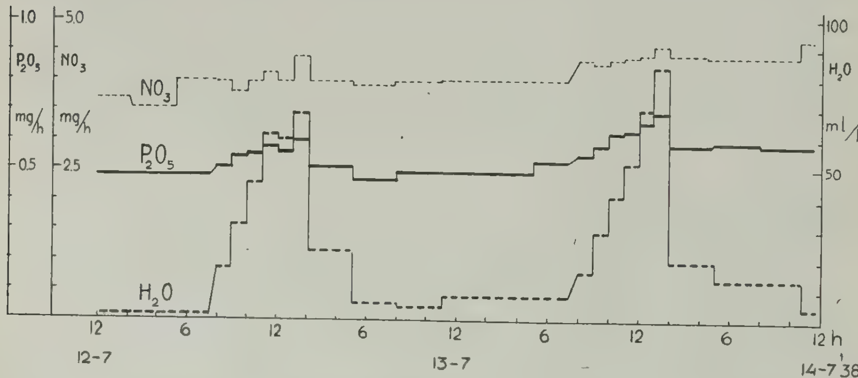

Fig. 4. *Sanchezia nobilis.* Rate of water intake and absorption of phosphate and nitrate by one plant during two days. (After VAN DEN HONERT, 1938).

Again, a ten- to twentyfold increase in water absorption was accompanied by only a small increase in phosphate absorption, whereas the nitrate absorption remained practically constant. Also in this experiment the concentrations were kept low (P_2O_5 below 5 p.p.m., NO_3 below 25 p.p.m.) and the pH was kept at a value 6.

One may wonder why these results differ so much from SCHMIDT's. Admittedly, he determined not only the uptake of nitrate and phos-

phate, but also that of potassium, calcium and magnesium, which ions were left out of account by VAN DEN HONERT. But also for the absorption of the two first named ones he found a strong correlation with the water uptake.

Two factors may be responsible for this descrepancy. Firstly, he used concentrations of the order of 50–100 times those used by VAN DEN HONERT. Moreover, he did not aerate his solutions and it seems probable that the asphyxiated condition of his *Sanchezia* roots had something to do with the phenomena he observed. HYLMÖ takes the high nitrate absorption with a relative ion uptake as high as 6 at low transpiration rates as a proof that the roots must have been metabolically active and could hardly have been suffering from oxygen deficiency. However, according to ARNON (1937), nitrate nutrition has the effect of compensating for lack of aeration, probably in connection with the high oxygen content of the nitrate ion.

It appears, therefore, that the evidence in favour of an ion absorption independant of transpiration is not so "astonishingly slight" as HYLMÖ seems to think. More critical experiments seem to be wanted. For this reason a number of short-term experiments were made with maize in water cultures under controlled conditions. The absorption rates of ammonium, nitrate, phosphate and potassium were determined at widely varying rates of transpiration.

MATERIALS AND METHODS

Maize seedlings of a single cross hybrid D × 9 reared from seed obtained from the plant breeding station "Centraal Bureau", Hoofddorp, were cultivated in pots with garden soil up to a size of about 50 cm. The roots were then freed from soil as much as possible by washing and the plants, usually two together, were placed into culture jars of 400–600 ml capacity with a WOODFORD and GREGORY (1948) solution of the following composition.

$Ca(NO_3)_2$	0,102 mM	$MgSO_4$	0,0975 mM
KNO_3	0,277 mM	KH_2PO_4	0,1505 mM

The solutions were continuously aerated and were renewed every three days.

After new roots had developed the still adhering soil was gradually cleared away, together with most of the original roots. After about four weeks a vigorous root system had developed, adapted to the water culture medium and suitable for absorption experiments.

The experimental procedure was very simple. The two plants, together with the wooden cover of the jar on which they were fastened, were lifted out of the solution and placed in another jar in which the desired experimental conditions prevailed. The roots were left there for adaptation during at least 20 minutes, after which a possible "rapid initial intake" was supposed to have been completed. Subsequently, the plants were transferred to another jar with identical conditions. After a certain time, depending on the concentration of

the ion in question and the expected absorption rate, the plant was taken out again.

The transpiration rate was determined by weighing plant and jar together on an automatic scale accurate to 0.3 g at the beginning and the end of every experimental period. The weighing took less than one minute.

As a matter of fact not the water uptake but the water loss from the plant was measured by this method, the evaporation from the surface of the solution being negligible during these short periods used. Now the changes in rate of water absorption by the roots, which are of interest here, will lag behind those of the transpiration loss (KRAMER 1937). However, this time lag is considered not to be of great importance in consequence of the adaptation period used with every change of conditions.

The nutrient solution was stirred and aerated by a continuous air stream. From time to time 1 ml samples were taken for colorimetric determination of the pH. As the solutions were only very slightly buffered care had to be taken not to bring the sample into contact with the air, because by loss of a little CO_2 the pH easily shifts towards the alkaline side. Therefore two drops of indicator solution (bromocresol purple 100 mg to 250 ml H_2O) were added to a 6 mm wide test tube and the sample pipetted into it in such way that while emptying the pipette its tip was kept under the surface of the solution in the test tube. One soon gets experience in mixing the indicator homogeniously in this way.

In the experiments to be described here the pH was kept at the value 6, by addition of a drop of 0.1 M NaOH or by supplying the aerating air stream, whenever necessary, with a small amount of carbon dioxide. The supply of CO_2 from a cylinder with pressure regulator was controlled by means of a needle valve and by observing the velocity of bubbling through a small washing bottle. This simple method appeared to be most helpful in regulating the pH of culture solutions in the range of pH 4.5–7.

The root temperature was kept at 20° C by placing the jars into a water thermostat.

The transpiration was influenced by putting the plants either in a sunny place in a glasshouse in the wind of a ventilator, or in a dark room with still air and with a high relative humidity. The transfer from one place to another took only half a minute. Perhaps it should have been more elegant to change the humidity factor only and to perform all the absorption experiments in the light. But as the greatest transpiration rates were obtained in strong sunlight and the light factor could not be kept constant anyway, this idea was abandoned. For the rest the results showed little evidence of a "change of mind" by the plants under conditions of light and darkness, in other words the status of the plants in respect to the carbohydrate supply of the roots etc., appeared to remain sufficiently constant. Indications of small changes will be discussed later on.

The absorption was measured by analysing samples of the nutrient

solution before and after the absorption period. For ammonium, nitrate and phosphate colorimetric methods were used. Ammonium and nitrate were determined by the Nesser and the phenol disulfonic acid methods respectively (ALLPORT 1947) and phosphate by the molybdenum blue method according to PARKER and FUDGE (1927). Potassium concentrations were determined by means of a BECKMAN flame photometer.

Care was taken to measure the absorption in the asymptotic part of the concentration-absorption curve, i.e. in a concentration range where the concentration factor has only little influence on the rate of absorption.

The influence of concentration on the rate of intake of nitrate, phosphate and ammonium by maize roots in water culture was known from experiments to be described elsewhere. Consequently, unless especially mentioned otherwise, the concentration of the named ions was well between the limits of 50 and 5 p.p.m. The same holds good for potassium, although the exact influence of the potassium concentration on the rate of intake was not yet known.

The desired very short experimental periods likewise made it necessary to use low concentrations, to the effect that within these periods still a considerable part (1/3 to 1/2) of the solute in question was absorbed. A same absorption intensity at higher concentrations either would require a much longer time or would give unreliable results with the use of colorimetric methods.

In calculating the quantities absorbed no corrections were needed for the decrease in the available volume of nutrient solution caused by the sampling for the pH determination (usually not more than 6 ml on a volume of 600 ml in every experiment), although the transpiration (determined as loss of weight) was corrected for it.

The loss of volume of the solution caused by the water absorption through the roots (taken equal to the quantity transpired) was duly taken into account in the computation of the ion absorption rates.

Ammonium series

In this series the roots of the maize plants were placed in the above mentioned WOODFORD and GREGORY solution in which the calcium and potassium nitrates had been replaced by equivalent amounts of sulfates, because it was not thought advisable to have more than one source of nitrogen in the solution. Ammonium was added as $(NH_4)_2SO_4$ with initial NH_4 concentrations varying from 20.5 to 9.7 p.p.m. The results are given in fig. 5.

Nitrate and Potassium series

A WOODFORD and GREGORY solution with nitrates replaced by an equivalent concentration of sulfates was used in those experiments where only the nitrate absorption was determined (Fig. 6, a, b). The necessary nitrate was supplied as KNO_3 with an initial NO_3 concentration of 47–48 p.p.m.

In the combined nitrate and potassium experiments (fig. 6, c–f)

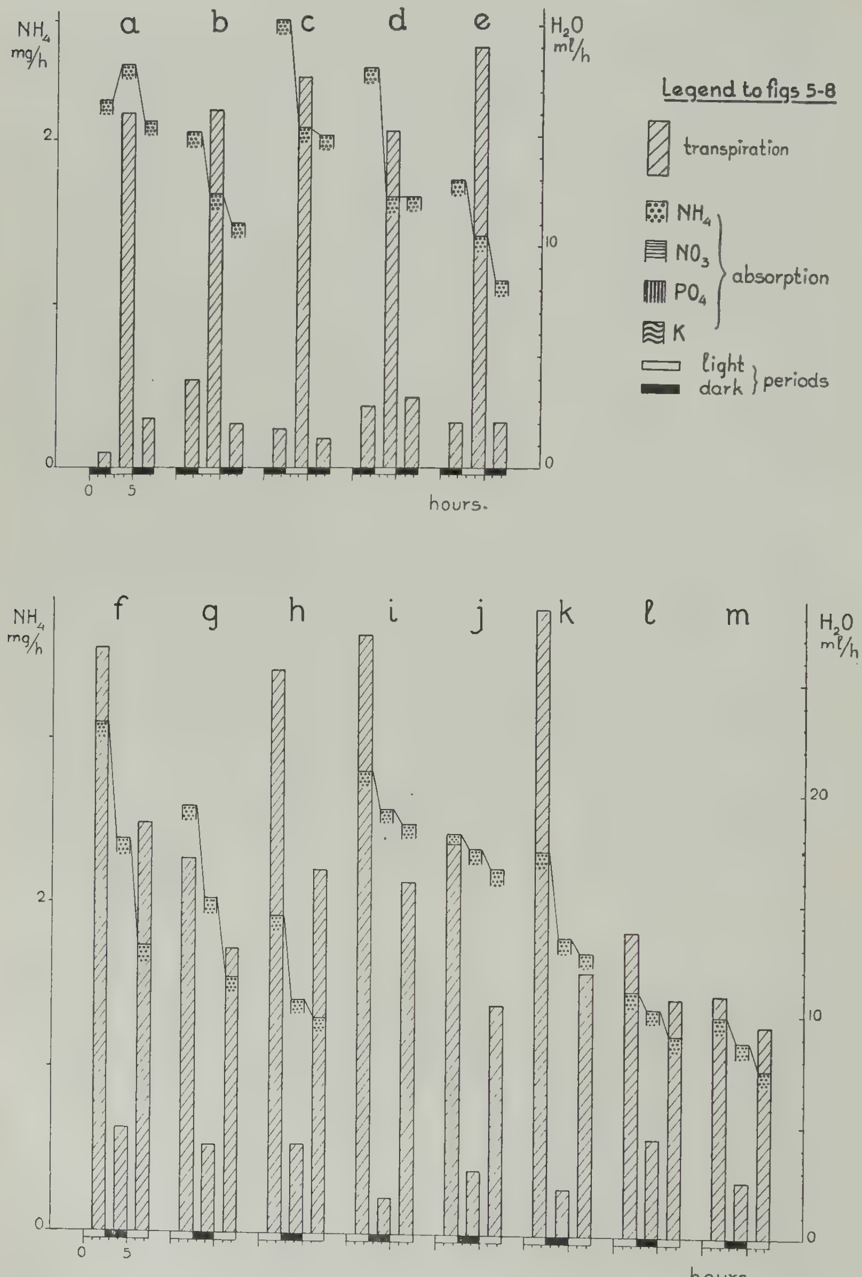

Fig. 5. Transpiration and ammonium absorption in maize.

a one-salt solution of KNO_3 was used in order to avoid the necessity of special precautions in the flame photometric determination of potassium. Here the initial K and NO_3 concentrations varied between 32–27 and 51–43 p.p.m. respectively.

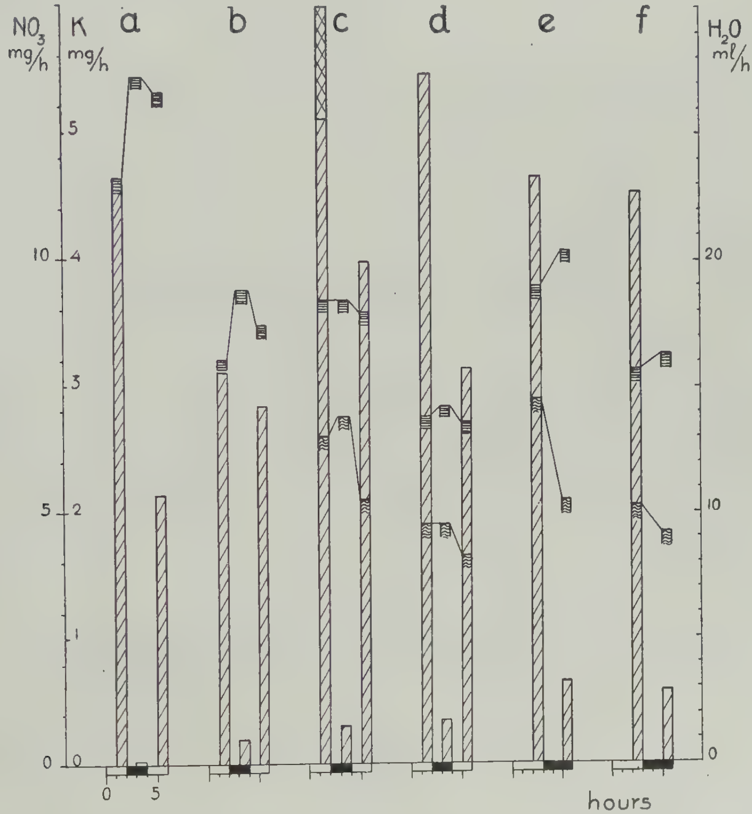

Fig. 6. Transpiration and absorption of nitrate and potassium in maize. Legend see Fig. 5.

Phosphate and Potassium series

In those cases where only the phosphate intake was studied (fig. 7, d–g) a Woodford and Gregory solution was used with an initial PO_4 concentration of 7.8 p.p.m.

For combined determinations of phosphate and potassium absorption a two-salt solution of KNO_3 and KH_2PO_4 was used for the reason mentioned in the preceding paragraph. The initial K and PO_4 concentrations were 53 and 12.9 p.p.m.

As is often done, the phosphate absorption rate has been calculated in terms of mg PO_4 per hour. It should be kept in mind, however, that maize roots absorb phosphate only in the form of monovalent H_2PO_4 ions, as could be shown in experiments to be published elsewhere. In this respect, therefore, maize behaves exactly like sugar cane

(VAN DEN HONERT, 1932) and shows similarity to rye and *Helodea canadensis* (OLSEN, 1953).

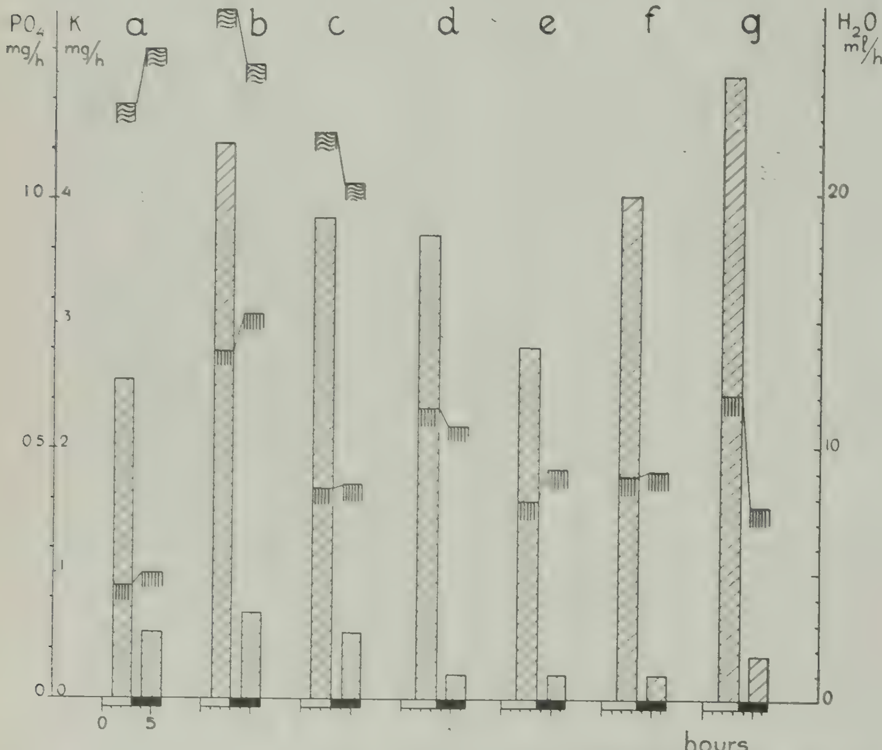

Fig. 7. Transpiration and absorption of phosphate and potassium in maize. Legend see Fig. 5.

Nitrate and phosphate series

Here the $Ca(NO_3)_2$ in the WOODFORD and GREGORY solution was replaced by an equivalent concentration of $CaSO_4$. KNO_3 and KH_2PO_4 were given in such a way that the initial NO_3 and PO_4 concentrations varied between 46–42 and 6.8–5 p.p.m. respectively.

In this series (see Fig. 8), as well as in the previous one, rather long absorption periods of 2–2.5 hours were used, because otherwise it would not have been possible to determine the fairly slow uptake of phosphate with sufficient accuracy.

In the last two experiments (Fig. 8, h and i) the plants were put under a bell glass during the light period in order to diminish the transpiration rate, so that the light factor constituted the only important difference between the two periods.

It must be mentioned that in some of these experiments the final phosphate concentrations at the end of the light and dark periods had decreased well below the asymptotic part of the absorption curve.

After the light periods of experiments g, fig. 7 and g, fig. 8 the PO_4 concentration was in both cases $\pm$ 2.0 p.p.m. This is still high enough to maintain a rate of phosphate intake 75 per cent of maximal.

Experimental results

The results of the experiments represented in Figs 5–8 are summarized in Fig. 9. In this figure the abscissa represents the "transpiration percentage" (i.e. dark transpiration rate in per cent of light transpiration rate) whereas the ordinate indicates the "ion absorption percentage" (i.e. the dark ion absorption rate in per cent of light ion absorption rate.).

At first sight it is clear that the majority of the "ion absorption percentages" cluster around the value of 100. In order to ascertain whether any significant relation bwetween transpiration and ion absorption is present the data obtained were submitted to a statistical treatment.

The "ion absorption percentages" were averaged over the different kinds of ions separately and the standard errors of these means calculated. Both these computations were made on the assumption that the method of observation (light-dark-light, light-dark, etc.) is without influence on the ion absorption percentage. (That this assumption was not contradicted by the data themselves was shown by an analysis of variance).

The results are shown in the following table.

Table 1. (Low "transpiration percentages")

Ion	Average ion absorption percentage	Standard error	Number of degrees of freedom	Confidence limits [1]	
NH_4	101	2.78	12	95	107
NO_3	107	1.66	13	103	111
K	97	5.65	6	83.2	111
PO_4	93	5.8	14	80.6	105

From the confidence limits it is evident that only the nitrate average differs significantly from 100; the difference is, however, in the opposite direction from the one to be expected. It is therefore reasonable to ascribe this difference not to the influence of water absorption but to some concomitant factor, e.g. to the strong illumination used to stimulate the water absorption during the light period. In order to check this hypothesis two experiments were made in which the plants were kept in a humid atmosphere during the illumination; the "transpiration percentages" were accordingly high. (See Fig. 8, h and i and Fig. 9, encircled symbols). The results are given in Table 2.

It is easily seen that there is no significant difference between the means of Table 1 and Table 2; moreover, the nitrate mean is signifi-

[1] We may expect with 95 per cent probability that the "true" mean lies within these limits.

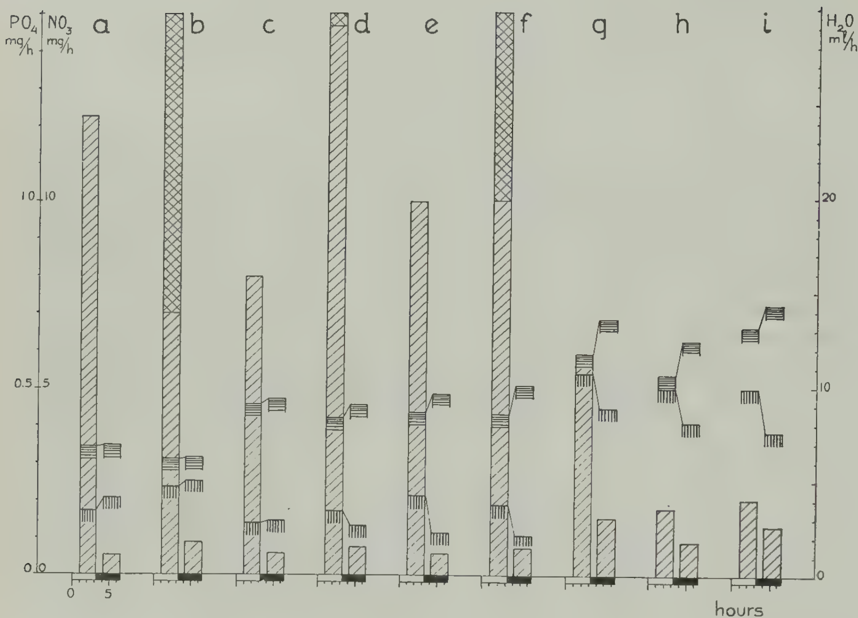

Fig. 8. Transpiration and absorption of nitrate and phosphate in maize. Legend see Fig. 5. The double hatching in b, d and f indicates a transpiration exceeding 30 ml/h.

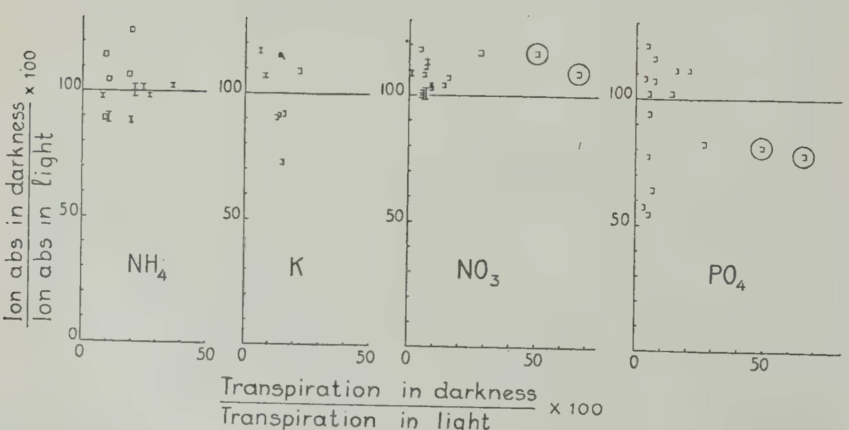

Fig. 9. Summary of the results represented in Fig. 5–8. Sequence of light and dark periods indicated as follows: □ dark-light-dark, I light-dark-light,] light-dark. The encircled symbols refer to experiments h and i in Fig. 8.

cantly greater than 100 in either table. So we can say that the data do not indicate any influence of water absorption on ion absorption. This result was confirmed by the analysis of variance mentioned above. It would have been desirable to make a greater number of the last named experiments. However, the season became too far advanced.

Table 2. (High "transpiration percentages")

Ion	Average ion absorption percentage	Standard error	Number of degrees of freedom	Confidence limits [1]	
NO_3	113	4.23	13	104	122
PO_4	79.5	15.4	14	46.5	113

Meanwhile, the general tendency of the nitrate absorption percentages in the dark to be higher than those during the preceding light period throws doubt on the assumption that during the short experimental periods used the plants remained in a completely constant status. Evidently the periods were long enough for the plants to have "changed their minds" already to a small extent. The same holds true for the phosphate absorption, where the variations seem to have something to do with the season. All the "ion absorption percentages" below 90 per cent (Fig. 9) were obtained in the autumn of 1954 after August 31th. Perhaps the carbohydrate content of the roots of the maize plants grown during shortening days was insufficient for a constant phosphate absorption during a dark period of three hours or more. If this were true the question remains why nitrate and phosphate behave differently.

Another phenomenon to be mentioned here is the rather steady decline of the ammonium absorption during practically all of the experiments (see Fig. 5). It is a phenomenon generally observed in those cases where maize roots grown in a solution containing nitrate as the only source of nitrogen were brought into an ammonium containing solution.

As mentioned before, the concentrations in the experiments were generally kept such, that the concentration factor had little influence on the ion absorption rate. Nevertheless, the ratio between the rates of absorption of two different ions determined simultaneously varied between wide limits, as shown in Table 3.

Table 3. Ratio of ion absorption rates determined simultaneously.

Values obtained	NO_3/K	NO_3/PO_4	K/PO_4
highest	3.08	72.3	53.4
average	2.47	34.2	31.6
lowest	2.09	16.2	15.9

This gives evidence of a certain independence between the different ion absorption mechanisms involved.

[1] We may expect with 95 per cent probability that the „true" mean lies within these limits.

Discussion

The conclusion from these experiments cannot be otherwise than that in maize roots in water culture, under the experimental conditions described and within the experimental errors, no influence of transpiration on the rate of absorption of ammonium, potassium, nitrate and phosphate could be demonstrated. The question arises why other authors, especially Hylmö and Brouwer, obtained completely different results.

In the first place they used different objects. It is possible that there are differences in protoplasmic or cell wall structure between roots of pea and broad bean on the one hand and maize roots on the other hand. It is imaginable, for that reason, that the transpiration-dependent part of the ion uptake (Hylmö's phase III), prominent in pea and broad bean, is negligible in maize. Besides, it is not certain that in maize calcium and chloride uptake would give the same picture as that of ammonium, potassium, nitrate and phosphate.

However, our results seem to be contradictory to some observations of Brouwer's (1953, l.c. p. 644), who stated a decided increase also of nitrate and phosphate absorption in young maize plants at higher transpiration rates. Two reasons may be advanced for this discrepancy. Brouwer used a Hoagland solution with higher phosphate and nitrate concentrations (44 and 158 p.p.m. respectively) than used in the present experiments. Also in Brouwer's experiments with broad bean and in those of Hylmö with peas, higher — mostly much higher— concentrations were applied than those used by the present authors. As in Hylmö's experiments the rate of "phase III" was found to be strongly dependent on the salt concentration, it might well be possible that such a transpiration-dependent ion absorption would become measurable also in maize at higher concentrations. The results thus far available seem to be in accordance with the assumption that the ratio between "phase II" and "phase III" is much higher in maize than in pea or broad bean, so that only at higher concentrations the influence of "phase III" might become apparent in maize. This would mean a quantitative rather than a fundamental difference between the two types of plants.

It might, however, also be surmised that the low concentrations used by the present authors would not permit the detection of "phase III", even if maize roots were identical with pea roots. However, if the "transpiration stream" taken up by the roots had the composition of the culture solution without dilution, the excess ion intake should have been apparent at the highest transpiration rates we measured. This maximal intake was calculated to be of the order of magnitude of 20, 30, 40 and 250 per cent for ammonium, potassium, nitrate and phosphate respectively. Therefore, unless a considerable dilution took place (cf. Hylmö) this surmise seems to be unlikely. Nevertheless, this last argument does not seem conclusive as yet.

SUMMARY

Maize plants in water cultures were submitted to conditions of high transpiration in the sun and low transpiration in the dark. Transpiration rates were determined together with those of ammonium, potassium, nitrate and phosphate absorption from solutions at pH 6 and 20° centigrade.

No significant influence of transpiration on ion absorption was found. These results seem to be at variance with those obtained by Hylmö with peas and by Brouwer with broad beans. However, the ion concentrations used were considerably lower than those used by Hylmö and Brouwer. Moreover, the possibility is discussed that the concentration- and transpiration-dependent component of the ion absorption might be great in pea and broad bean and small in maize. The seeming contradiction would then be reduced to a quantitative difference.

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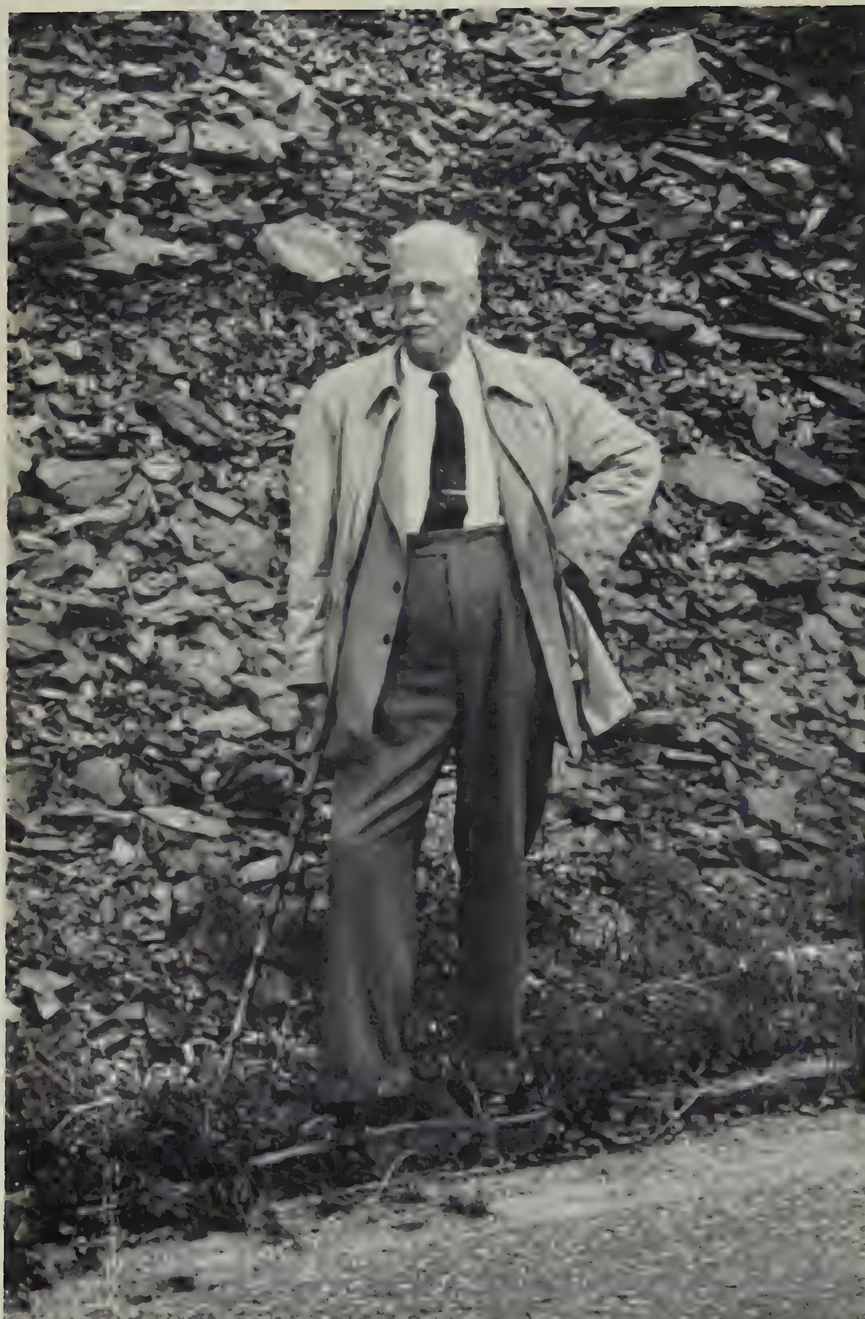
REFERENCES

Allport, N. L., 1947. Colorimetric Analysis. London, Chapman and Hall Ltd.
Arnon, D. I., 1937. Soil Sc. 44 : 91–122.
Bötticher, R. and L. Behling, 1939. Flora, N. F. 34 : 1–44.
Brewig, A., 1937. Zeitschr. f. Bot. 31 : 481–540.
Brouwer, R., 1953. Proc. Kon. Akad. Wet. C 57 : 68–80.
Brouwer, R., 1954. Acta Botan. Neerl. 3 : 264–312.
Broyer, T. C. and D. R. Hoagland, 1943. Am. J. Bot. 30 : 261–273.
Freeland, R. O., 1937. Am. J. Bot. 24 : 373–374.
Haas, A. R. C. and H. S. Reed, 1927. Bot. Gaz. 83 : 161–172.
Hasselbring, H., 1914. Bot. Gaz. 57 : 72–73.
Hoagland, D. R., 1944. Lectures on the Inorganic Nutrition of Plants. Chron. Bot. Comp., Waltham Mass.
Hoagland, D. R. and T. C. Broyer, 1942. J. Gen. Physiol. 25 : 865–880.
Honert, T. H. van den, 1933. Verslag 13e Vergadering Vereeniging Proefstations Personeel (Buitenzorg, Java) : 7–20.
Honert, T. H. van den, 1938. Handelingen 8e Ned.-Indisch Natuurwetensch. Congr.: 365–367.
Huber, B., 1923. Zeitschr. f. Bot. 15 : 465.
Huber, B., 1954. Naturwiss. 40 : 180–185.
Humphries, E. C., 1952. J. Exp. Bot. 3 : 291–309.
Hylmö, B., 1953. Physiol. Plant. 6 : 333–405.
Kramer, P. J., 1937. Am. J. Bot. 24 : 10–15.
Kramer, P. J., 1949. Plant and Soil Water Relationships. McGrawhill Book Cy, New York.
Kreyzi, R., 1932. Zeitschr. f. Pfl. Ern. Düng. u. Bodenk. A 25 : 156–179.
Kiesselbach, T. A., 1916. Bull. Agr. Exp. Sta. Nebraska, Research Bull. 6.
Mendiola, N. B., 1922. Phillipp. J. Sc. 20 : 639–655.
Michael, G. and E. Wilberg. 1951. Zeitschr. f. Pfl. Ern. Düng. u. Bodenk. N. F. 52 : 242–258.
Muenscher, W., 1922. Am. J. Bot. 9 : 311–329.
Olsen, C., 1953. Physiol. Plant. 6 : 844–847 and 848–854.
Parker, F. W. and J. F. Fudge, 1927. Soil Sc. 24 : 109.
Petrischek, K., 1953. Flora 140 : 345–385.
Phillis, E. and T. G. Mason, 1940. Ann. Bot. N. S. 4 : 645–650.
Robertson, K. M., 1940. Nature 145 : 937–938.
Schloesing, M. Th., 1869. Ann. Sc. Nat. 5 Sér. Bot. 10 : 366–369.
Schmidt, O., 1936. Zeitschr. f. Bot. 30 : 289–334.
Sorauer, P., 1880. In: Wollny, Forschungen über Agrikulturphysik 3 : 351–490.
Wey, H. G. van der, 1936. Verslag 16e Vergadering Vereeniging Proefstations Personeel (Djember, Java) : 109–119.
Woodford, E. K. and F. Gregory. 1948. Ann. Bot. N. S. 12 : 335–370.
Wright, K. E., 1939. Plant Physiol. 14 : 171–174.



IN MEMORIAM

PROF. DR. A. A. PULLE

BY

J. LANJOUW
Botanical Museum and Herbarium, Utrecht

(received March 17th, 1955)

After a long and severe illness Prof. Dr. A. A. PULLE died on February 28th 1955. It was only early in December of last year that PULLE informed the board of our Society that he felt no longer able to continue his task as secretary of the editorial board of the "Acta Botanica Neerlandica" and asked to be replaced by a younger botanist. It was planned to give him in this number of our periodical some warm words of thanks for the very important services he had rendered for the sake of promoting botanical science in our country. Our hope that he would have had some more time to live has been in vain. We can now state only our thankfulness to his memory and give a retrospective view on the life of one of our best members.

AUGUST ADRIAAN PULLE was born on January 10th 1878 at Arnhem. A remarkable day for a plant taxonomist, it being exactly 100 years after the death of LINNAEUS. He passed his schoolyears in his native town and during those years he was active in botanising in the interesting surroundings of that city. His floristic knowledge of the Netherlands got a sound basis in those years. In later years, he occasionally used to refer to those happy moments when he discovered rare species on these private excursions.

As a student in pharmacy PULLE came to Utrecht university in 1897. As one of his teachers he found there the young Dr. F. A. F. C. WENT, who a year before had been appointed in the chair for General Botany. It was through WENT's lessons that PULLE's interest in botany awoke again and that he decided to take biology for his master's degree. WENT recognized PULLE's ability for taxonomy and through WENT's recommendation PULLE was chosen as a botanist to accompany the Saramacca R. expedition to Surinam in 1902. This first journey in the tropics was of immense value for PULLE's later work. Since that time he has been one of our

big promotors of botanical investigations in the tropics in general and in Surinam in particular. In 1906 he got his doctor degree first class honours on a thesis entitled "An Enumeration of the vascular Plants known from Surinam". This work has since been the basis for all those engaged with taxonomic studies of the Guianas.

In 1906 he made a trip to Java. In 1912/13 he accompanied as a botanist the third New Guinea Expedition and in 1920 he again made a collecting trip in various parts of Surinam. In 1938 he visited Brazil on the occasion of the first South American Botanical Congress. Finally he took part in the second South American Botanical Congress in the Argentine in 1948 and on his way back to Europe he paid a short visit to Surinam.

In 1906 he was appointed Lecturer and in 1914 Professor in Plant taxonomy and Plant geography at the Utrecht university, and Director of the Botanical Museum and Herbarium. Under his direction this rather small collection grew out to one of the best herbaria for the Northern South American region. In 1920 the formerly privately owned garden "Cantonspark" at Baarn (20 km NE of Utrecht) came as a botanical Garden of the university under his supervision and here too, Pulle made every effort to enrich the collections.

About his scientific work and especially about all he did for the botanical investigation of Surinam we will report elsewhere. Also we will be short about his work as a university professor. But it may be stated that the number of plant taxonomists in the Netherlands early in this century was very small and that if we can say now with some pride that our country is well represented in the world family of plant taxonomists, we will have to acknowledge that this is mainly due to Pulle.

In this place, however, we must pay tribute to his activities for the Royal Dutch Botanical Society. On February the 7th, 1904, Pulle became a member and he served the Society in many functions. From 1909–1916 he was secretary of the commission for the floristic investigation of the Netherlands. From 1914–1916 he was secretary of the board of the Society. From 1934–1936 and from 1942–1945 he was president of the commission for biosociology. From 1947–1948 he was president of the commission for plant taxonomy and plant geography. Apart from his activities as an ordinary member these services together rendered to the society by one person, are already something for which we have to be grateful, but far above that goes the work he did for the publications of our society. From 1923–1952 he was secretary of the editorial commission for the "Recueil des travaux botaniques néerlandais" and from 1952 – Jan. 1955 of the same commission for the "Acta

Botanica Neerlandica". For thirty two years the editing of the Society's periodical depended on PULLE. He perused the manuscripts and he reported on them to the commission, he talked and corresponded with the publishers and printers, he read the proofs, he had to please the authors, the printers and the society, and he did the work carefully and usually without losing his sense of humour. The society expressed its greatest appreciation for this outstanding work by appointing PULLE honorary member on the occasion of the celebration of the society's centenary in 1945. I know that PULLE highly appreciated this recognition for his work. In the last year of his life his illness made it impossible for him to continue his work in the way he would have liked but he still devoted what was left him in activity to this editorial work. It was only at the very end that he decided to ask the society's board to accept his resignation. He felt that his time had come and he liked to hand over his function at a moment that he was still able to do so. He was very glad that his pupil Dr. F. P. JONKER was appointed his successor.

For more than 50 years PULLE was an active botanist and during these years he was promoting botanical science in general but especially in his own country, for his Dutch Society, his University and his Institute. We gratefully pay a tribute to his memory for what he did and for the friendship he gave so many of us.

ACTA BOTANICA NEERLANDICA, Vol. 4 (2), 1955

PLANT SUCCESSION ON FORMER TIDAL LANDS IN THE NORTHEASTERN POLDER[1]

BY

A. C. BOER

(received Dec. 15th, 1953)

The area to be discussed in this article was formed along the dikes of the former Zuidersea. In times past year after year the sea deposited its material along the shore and finally new land came into being. It is not known, however, when this took place, nor if the process was enhanced by man by means of plantations of *Schoenoplectus lacustris*, as was the case on the nearby Island of Kampen. Nowadays the area is considered to be the "hay barn" of the adjacent region and it is well established that these coastal lands have been under cultivation for several decennia.

Before the construction of the enclosing dam of the Zuidersea, these offshore lands were frequently flooded, since they were protected only against high water levels by low summer dikes. These inundations occurred mainly during winter, but occasionally also in summer when strong gale floods overflowed the area. In this way much silt was deposited, acting as a natural fertilizer. A luxuriant but predominantly saline vegetation developed, in which *Juncus gerardi* dominated to such an extent that people characterised the cover as a "heavy grass sod."

As a consequence of the enclosing of the Zuidersea the floods, which used to bring so much fertile silt, occurred no more and a gradual drop in the salt content of the soil took place. The original predominantly saline grass vegetation receded more and more and became replaced by glycophytes. Gradually the "heavy grass sod" became transformed into a "lighter" one, due to the receding of *Juncus gerardi*. The production of the grass cover decreased quantitatively; its quality, however, improved, also when we consider the after-math. Still the lower lying parts of the area remained rather strongly saline.

The strongest interference in the development of the vegetation of the area occurred after the reclamation of the Northeastern Polder. Prior to this event the water level of the IJssel Lake, formed after the enclosure of the Zuidersea, influenced the water table of the areas under discussion. The ground water table in the Northeastern Polder,

[1]) The Northeastern Polder is a reclamation district in the former Zuidersea. A polder" is an area reclaimed from the sea by the construction of a dam and subsequent pumping out of the water present between this dam and the former coast line.

however, is 15 to 19 feet beneath the level of the water in the IJssel Lake. Since the Northeastern Polder is not separated from the former coastal polders by a canal or other mass of water, the areas bordering this reclamation district suffered considerably from a substantial lowering of their water table. This phenomenon found its expression in a change in the composition and development of the grass cover. In order to ascertain this influence of the reclamation of the Northeastern Polder on the grass vegetation of the former coastal regions the vegetation has been mapped at many localities and at frequent intervals since 1939. However, from the first botanical reconnaissances, performed before the actual reclamation of the Northeastern Polder, it appeared, that even in this period the vegetation was changing rapidly, due to the absence of silt carrying floods and a continuing desalinization. Consequently, it will not be possible to ascertain with absolute certainty the direct influences of the reclamation of the polder on the development of the vegetation.

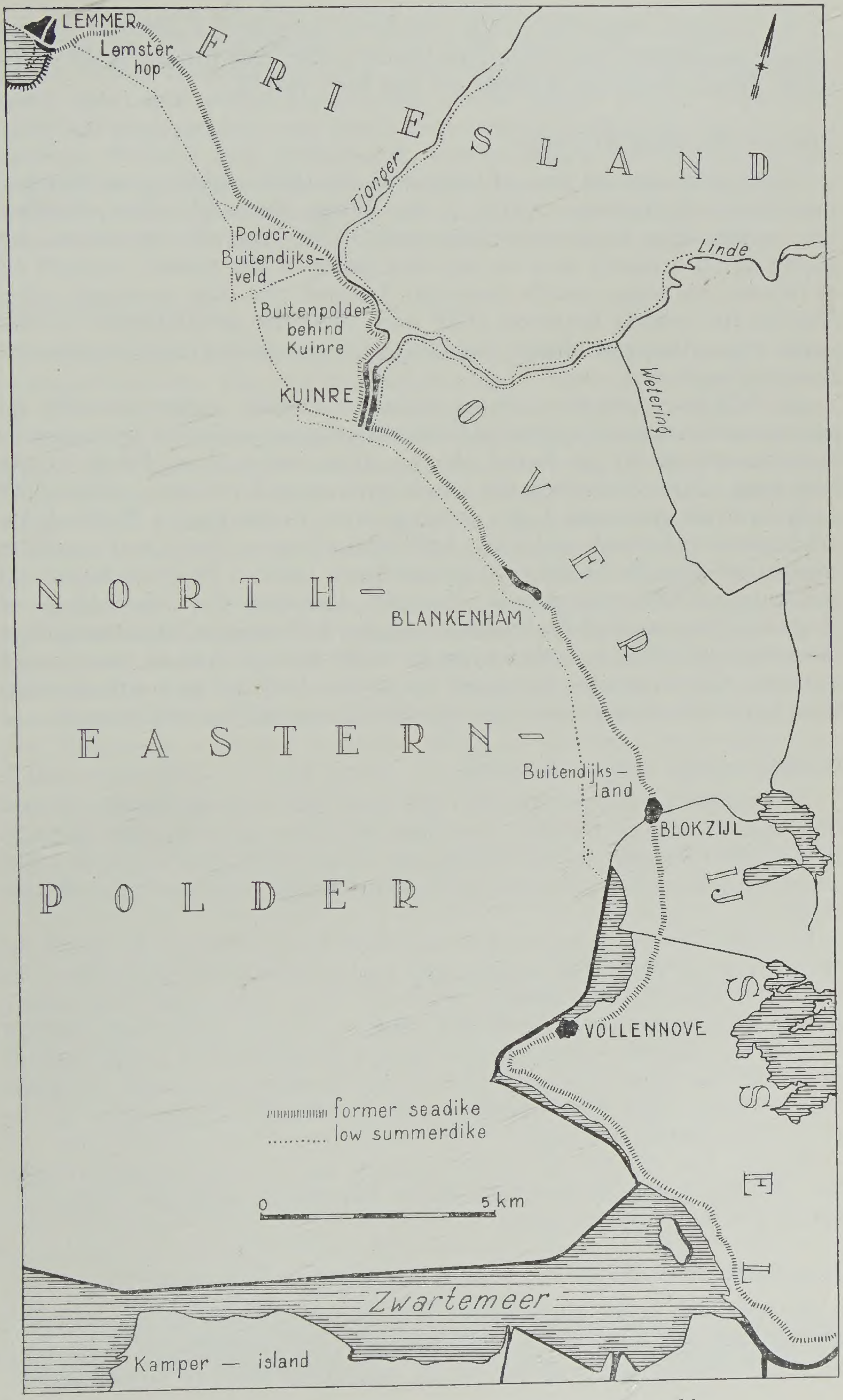
In the following paragraphs a description will be given of the changes that took place in the grass cover of the offshore polders, due to the action of the overall group of factors mentioned above.

The Lemsterhop

The soil of this polder consists of clay and sandy loam, underlain by a subsoil of coarse sand. The coarse sandy layer shows its strongest development near the summer dike that used to protect the area against normal high water levels of the Zuidersea. In the region near the old sea dike peat can be found at a depth of about 2 feet; this section is also the wettest part of the polder.

Before the enclosure of the Zuidersea the grass sod of the Lemsterhop would have shown similar relationships to the vegetation of the Blokzijler Uiterdijk Polder as those that can be found between the saline offshore vegetation north of Enkhuizen and the plant cover in the Polders in that area lying more to the south. Although the vegetation of 1939 still shows a strongly saline character, a transition phase of the *Armerieto Festucetum* begins to appear, in which the grass cover is already interspersed with *Alopecurus bulbosus* and *Bromus racemosus*. It appears from the changes in the botanical composition, that these species become more abundant when the percentage of glycophytes in the vegetation increases. On the other hand an apparent decline in the predominance of these species can be noticed when *Cynosurus cristatus* and or species of the *Arrhenatheretum elatioris*-association become more prevalent. No other species characterize so strikingly this saline-glycophytic phase and consequently this phase in the succession of the vegetation is called the association of *Alopecurus bulbosus* and *Bromus racemosus*.

The constancy of this association will have to be established from more and particularly more regional material. The association is intermediate between the *Armerieto Festucetum* and the *Lolieto cynosuretum* and or, the *Arrhenatheretum elatioris*. This association can be included



Map of the former tidal lands in the Northeasternpolder.

in the *Armerion* order due to the consistent presence of *Armerion* species. *Alopecurus bulbosus* can scarcely be found in the area inland of the dikes, while *Bromus racemosus* is observed but very rarely.

Polder Buitendijks-veld

This polder has an area of 625 acres. In 1939 a fairly pure stand of the *Armerio Festucetum* covered a low lying, wet and saline, limeless clay ridge, that is underlain by peat. This type of vegetation also occurred on a sandy area at the west point of the polder, formed by overflows carrying sandy material behind the low summer dike. During the period between 1939 and 1950 the development of this saline vegetation ran almost parallel to the succession described for the Lemsterhop area.

In 1939 the *Armerion* species occurred already rather sparsely on loamy soils underlain by peat. At that time *Carum carvi* and *Chrysanthemum leucanthemum* could be found in the grass vegetation. Prior to the enclosure of the Zuidersea the whole area must have been covered by a glycophytic grass sod. Later on large areas in the Polder Buitendijks-veld were reclaimed and only half of the region remained under a vegetation of grass. During the period from 1945 to 1950 the botanical make-up of this vegetation changed towards the association of *Alopecurus bulbosus* and *Bromus racemosus.* In this phase of the association, however much fewer *Armerion* species were present than at more moist habitats. Consequently the type has to be classified as a sub-association, with *Festuca rubra* and *Agrostis stolonifera* as differential species.

Buitenpolder behind Kuinre

This polder covers an area of 1250 acres and is composed of a heavy clay soil, underlain by peat. In these soils lime is no longer present. Before the enclosure of the Zuidersea a strongly saline vegetation, in which *Juncus gerardi* predominated, covered the western part of this area.

In 1939 the grass vegetation was still rather saline. It could be mapped, however, as a transitional stage toward the association of *Alopecurus bulbosus* and *Bromus racemosus.* This association was rather purely developed in 1945 and 1950. Particularly *Triticum repens* spread intensively and this can be taken as an indication, that in this polder the influence of the reclamation of the Northeasternpolder was felt more strongly than in the Lemsterhop, where this same species occurs in limited distribution only.

Finally, the eastern part of this polder has been in its present state for a longer period of time and hence must have undergone desalinization for many more years.

The narrow coastal area between Kuinre and Blokzijl

In these tidal lands much material used to be dug for the construction and upkeep of the sea dikes. Consequently this coastal area has a very irregular surface, even as far as the neighbourhood of Genemuiden.

The vegetation can be classified under the same heading as the plant cover of the Buitendijks-land. The grass vegetation is quite varied: *Juncus gerardi*, *Heleocharis palustris* and other species can be found at the lower spots and many glycophytes at the higher places. Sometimes beautiful contrasts are caused by these variations in habitat. Particularly between Blokzijl and Vollenhove, where before the mowing of the vegetation the higher spots are white due to the predominance of *Anthriscus silvestris* while later on in July and August *Heracleum sphondylium* in its turn gives these habitats a white appearance.

Buitendijks-land

In this area two terraces, enclosing a lower region, gently slope towards the west. The soil consists of a light loam, underlain at about $1\frac{1}{2}$ ft by fine sand. This sand corresponds to the sand of the coast. Before the reclamation of the Northeastern Polder a kind of sandbank, about two miles long, was situated along the coast in the direction of Blankenham. This bank was separated from the coast by a stretch of water and it supported a vegetation in which *Scirpus maritimus* dominated and facies of *Schoenoplectus tabernaemontani* were present. At the highest spots of the sandbank saline species could be found, accompanied by *Urtica dioica*, *Bidens tripartitus*, *Epilobium angustifolium* and *Epilobium hirsutum*. The bottom of the intervening stretch of water mentioned above was a rather muddy substratum lying on sand, particularly close to the sandbank. Along the shores of this water a luxuriant vegetation of beautiful zones of *Bidens cernuus*, *Senecio paluster* and *Ranunculus sceleratus* occurred, while at the least developed spots *Typha angustifolia* formed dense stands, mixed with *Typha latifolia*. On the slopes of the sandbank, along its borders and along the coast as well, the vegetation was predominately *Pragmites communis*, mixed with *Phalaris arundinacea* and *Bidens tripartitus*. This whole pioneer vegetation showed fascinating aspects.

During the period between 1939 and 1945 the grass vegetation of the lower zone mentioned above was in a stage of transition, from the *Armerieto Festucetum* towards the association of *Bromus racemosus and Alopecurus bulbosus*. In 1950 the latter had changed into the *Arrhenateretum elatioris*. Moreover a strong spreading of *Rhinanthus major* could be noticed; this is a striking phenomenon in all these offshore areas. At moist habitats *Lychnis flos-cuculi* appears too. This sequence seems to be the succession on grassland that is undergoing desalinization and the agricultural care of which leaves much to be desired due to its extensiveness.

In 1939 the grass vegetation on the slope of the terrace facing the west offered a rather good picture of the association of *Bromus racemosus* and *Alopecurus bulbosus*. Before the enclosure of the Zuidersea this grass cover must have been moderately saline. Since 1945, however, the vegetation changed into a *Lolieto Cynosuretum*.

It can be deduced from the absence of *Armerion* species in 1939, that before the enclosure of the Zuidersea the grass vegetation at the

foot of the former sea dike must have contained but a few halophytes. The grass cover is rich in herbs, particularly in *Anthriscus silvestris* and *Heracleum sphondylium.* In 1945 the vegetation was rather heterogeneous but at the moment a fairly pure *Arrhenatheretum elatioris* has developed. It appears from the given description of the succession in the grass vegetation in these offshore polders, that the following succession has taken place: *Armerieto Festucetum* → association of *Alopecurus bulbosus* and *Bromus racemosus* → *Lolieto cynosuretum* → *Arrhenatheretum elatioris.*

Conclusions

Considering the desalinization of the Buiten polder behind Kuinre, it is striking that in 1939 this area, situated at a level of about 2 feet under N.A.P.,[1] was covered with a vegetation consisting of 50 % saline species, while at a higher altitude the Lemsterhop showed among its component species 80 % belonging to this ecological group. This is mainly due to the fact, that the Lemsterhop, not considering a single annual mowing of the grass, remained undisturbed. In the period between 1945 and 1950 the percentages of saline species mentioned above were reduced to 18 % and 20 % respectively. This decrease was due to the fact that both polders are located within the sphere of influence of the Northeastern Polder.

In the Buitendijks-land, before as well as some years after the reclamation of the Northeastern Polder, the grass vegetation growing at a level of about $\frac{1}{4}$ ft above N.A.P. showed a stronger saline influence than the vegetation growing at the foot of the former sea dike at a level of about $\frac{1}{4}$ ft beneath N.A.P. It is apparent, that the stronger saline character of the first mentioned vegetation is a result of an earlier continuous contact with the former Zuidersea.

From the saline character of the Lemsterhop, the Buiten polder behind Kuinre and the Buitendijks-land (percentages of saline species in the vegetation in 1939 80, 50, and 35 respectively and in 1950 20, 18 and 10 respectively) a decreased saline influence is evident in a southern direction. This influence is still more pronounced south of Blokzijl due to the former influence of the river IJssel. In this area the factor "floods rich in silt" is present too. The same holds for the Kamper Island, although here at low spots some saline influence can still be noticed.

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[1] N.A.P. stands for a standard waterlevel at Amsterdam, used for reference purposes.